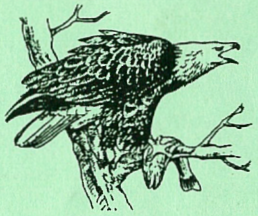
BIOLOGICAL OPINION
ON THE IMPACTS OF FOREST MANAGEMENT AND OTHER ACTIVITIES TO THE GRAY BAT, BALD EAGLE, INDIANA BAT, AND MEAD'S MILKWEED ON THE MARK TWAIN NATIONAL FOREST MISSOURI



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I. CONSULTATION HISTORY

In 1984, the Forest Service requested formal consultation with the Service on the LRMP for the MTNF. On August 8, 1985, the Service issued a non-jeopardy biological opinion for seven species: bald eagle, Indiana bat, gray bat, Ozark big-eared bat (*Corynorhinus townsendii ingens*), Curtis' pearly mussel, pink mucket pearly mussel, and the Higgins' eye pearly mussel (*Lampsilis higginsi*).

In May 1998, MTNF provided a draft Programmatic Biological Assessment (DPBA) as part of a reinitiation of informal consultation to this office on the potential effects of actions outlined in the LRMP to all federally-listed species in Missouri. The need for reinitiation of consultation was based on "continued research and inventory of TE species populations on the forest, as well as a refinement of our knowledge of these species' habitat requirements" (U.S. Forest Service 1998). Our office reviewed the DPBA and provided comments back to the MTNF dated May 27, 1998. Following incorporation of many of the comments provided by this office, the MTNF resubmitted a second draft Programmatic Biological Assessment on June 18, 1998. In August 1998, our office provided additional comments on the second draft of the Biological Assessment to the MTNF. On August 18, 1998, representatives of the Service and Forest Service met at the Mark Twain National Forest's headquarters to discuss the Service's comments. In a letter to the project file dated August 31, 1998, the Forest Service addressed concerns raised by the Service. In a letter dated September 8, 1998, the Forest Service submitted a revised and final Biological Assessment (BA). In their BA, the Forest Service concluded that ceratin actions to implement the LRMP would be likely to adversely affect the Indiana bat, gray bat, bald eagle, and Mead's milkweed. They also determined that the adverse effects identified in the BA could not be removed through informal consultation. Consequently, the submission of a final BA was accompanied by a request by the Forest Service for formal consultation on the potential effects of actions outlined in the LRMP on the Indiana bat, gray bat, bald eagle and Mead's milkweed.

In a letter dated February 10, 1999, the Service requested an extension of 20 days for delivery of the draft biological opinion. This request was granted by the Forest Service in a letter dated February 24, 1999. The Service delivered an initial draft biological opinion directly to personnel of the MTNF on March 8, 1999. On March 12, March 22, March 30, and April 19, the Service discussed with staff of the MTNF the terms and conditions associated with the reasonable and prudent measures, and conservation recommendations outlined in our initial draft biological opinion, and written comments received from the Forest Service dated March 17, March 24, and April 1, 1999. After considering comments received from your agency regarding the Service's March 8 draft biological opinion, we prepared and delivered a second draft to personnel of the MTNF on April 26, 1999. On May 14, 1999, the Service discussed the April 26, 1999 draft with personnel of the MTNF. We received written comments from the Forest Service on the April 26, 1999 draft dated May 14, May 21, and May 24, 1999. After considering comments the Service received from the Forest Service regarding our April 26, 1999 draft, we prepared and delivered a final draft biological opinion to personnel of the MTNF on June 2, 1999. We received comments on our June 2, 1999, final draft from Garry Houf of the MTNF during a telephone conversation with Dr. Paul McKenzie of our staff on June 8, 1999.

In their request for formal consultation of September 8, 1998, the Forest Service determined that activities outlined in the LRMP would not likely adversely affect the Topeka shiner (*Notropis topeka*), Hall's bulrush (*Schoenoplectus hallii*), running buffalo clover (*Trifolium stoloniferum*), Tumbling Creek cavesnail (*Antrobia culveri*), Curtis' pearly mussel (*Epioblasma florentina curtisi*), and pink mucket pearly mussel (*Lampsilis abrupta*). The Forest Service further requested our concurrence on these effect determinations. In a letter dated October 5, 1998, the Service: 1) concurred with the Forest Service's determination that certain actions to implement the LRMP would be likely to adversely affect the Indiana bat, gray bat, bald eagle, and Mead's milkweed, 2) indicated that the initiation package associated with the Forest Service's request for formal consultation was adequate, and 3) announced that formal consultation between the two agencies had begun. In the same letter, the Service concluded that activities outlined in the LRMP were not likely to adversely affect running buffalo clover or the Tumbling Creek cavesnail and stated that a "no effect" determination was appropriate for Topeka shiner, Curtis' pearly mussel, pink mucket pearly mussel, and Hall's bulrush. Our rationale for these determinations were discussed at length in our October 5, 1998 correspondence. Because the Ozark big-eared bat (*Corynorhinus townsendii ingens)* and the Higgins' eye pearly mussel (*Lampsilis higginsi*) are both considered by the Service and the Missouri Department of Conservation to be extirpated from the state, they are no longer considered in this opinion.

The Service requested additional information to clarify activities on the MTNF or to clarify comments made in the Forest Service's Biological Assessment by telephone on February 1, 4, 5, 8, 16, 23, 27; March 2, 3, 5, 8; and April 20, 22,1999. This information was received by facsimile from Jody Eberly (Forest Service- MTNF) on February 1, 4, 5, 8, 16; and March 2, 3, 5, 8, 1999 (in litt.), by facsimile from Garry Houf (Forest Service- MTNF) on February 5 and April 23,1999 (in litt.); by electronic mail from Houf on February 8, 22, and 29, 1999 (in litt.), and by telephone on April 20, 1999 (Houf pers. commun. April 20, 1999).

II. BIOLOGICAL OPINION

Description of the proposed action

As defined in 50 CFR 402.02, "action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or upon the high seas. The "action area" is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. The direct and indirect effects of the actions and activities from the federal action must be considered in conjunction with the effects of other past and present Federal, State, or private activities, as well as cumulative effects of reasonably certain future state or private activities within the action area. The Service has determined the action area for this project includes the entire MTNF lands. This biological opinion (opinion) addresses only those actions for which the Service believes adverse effects may occur. In their BA, the Forest Service outlined those activities in the LRMP that would adversely affect the Indiana bat, gray bat, bald eagle, and Mead's milkweed. The Service concurs with this determination and the following biological opinion addresses whether

continued implementation of the LRMP on the MTNF is likely or not likely to jeopardize the continued existence of these species.

This biological opinion addresses a variety of management directions and associated activities that are planned, funded, executed, or permitted by the MTNF. These activities are implemented in accordance with the provisions contained in the LRMP. The LRMP is a general programmatic planning document that provides management goals, objectives, and standards and guidelines under which project level activities (e.g., timber sales, stand improvement, wildlife habitat management, road construction, special uses, etc.) may be planned and implemented to carry out the management direction on the MTNF. Land use allocations are made and outputs projected based upon the direction established in the MTNF's LRMP. All project level activities undergo National Environmental Policy Act (NEPA) review by appropriate Forest Service personnel when proposed, as well as assessment of project effects to federally listed species in compliance with Section 7 of the ESA. The LRMP establishes multiple use management area prescriptions (including associated standards and guidelines) for future decision making which are adjustable (via monitoring and evaluation) through amendment and revision. The proposed action includes all individual projects currently ongoing, as well as all specific actions implemented from the LRMP in the future.

Under the LRMP, the direction of forest management on MTNF is based on several forest management goals as outlined in the forest plan. Management goals receiving consideration include multiple use, recreation, wilderness, wildlife, timber, range, transportation system (i.e., road construction, maintenance, and management), minerals, fire, soil, water, and air management goals; and land adjustment program goals (i.e., land exchanges, increased public access, etc.) (U.S. Forest Service 1986). Of these, the primary current emphasis (34% of activities on the MTNF) is devoted to the management of wildlife habitat to "maintain and enhance populations of native and desired non-native vertebrates" (U.S. Forest Service 1986). Under this emphasis, habitat is to be provided not only for "native and non-native vertebrates", but for "indicator species", "consumptive and nonconsumptive fish and wildlife use", and "wildlife species requiring specialized habitat including those recognized by both Federal and State authorities as being threatened, endangered, rare, or sensitive." (U.S. Forest Service 1986). Following wildlife habitat (34%- 508,200 acres), other current management emphases on the MTNF in decreasing order of abundance are:

- the management of shortleaf pine within its natural, historic range (29%- 439,200 acres);

- semi-primitive, motorized (i.e., some road access to areas allowed), recreational opportunities made available through the "management of natural vegetative communities and their successional stages"- achieved through various types of timber, wildlife, and range management objectives (17.8%- 265,800 acres);

- semi-primitive, non-motorized (road access prohibited), recreational opportunities made available through the "management of natural vegetative communities and their

successional stages"- achieved through various types of timber, wildlife, and range management objectives (5%- 71,600 acres);

- intensive management of hardwood species capable of yielding high value hardwoods- achieved through various types of timber, wildlife, and range management objectives and allows for road access for recreational opportunities (4.4%- 65,800 acres);

- wilderness designation (4%- 63,200 acres)- managed solely by "the forces of nature", except that prescribed fire can be used to "aid, maintain, or restore natural plant communities or threatened and endangered species" if approved by the Chief of the Forest Service;

- "lands not needed to meet projected demands for the next 50 years or to lands that are currently uneconomical for resource investment" (i.e., lands that are "low in output capability or have an unfavorable benefit-cost relationship")- "plant and animal diversity and successional stages are determined primarily through the forces of nature", and such lands are considered unsuitable for timber production (1.7%- 25,900 acres);

- a variety of "special areas" other than Wilderness that provide "protection of unusual environmental, recreational, cultural, or historical resources, and for scientific or educational studies" (1%- 15,800 acres);

- "management of natural vegetative communities and their successional stages to produce moderate resource outputs from a managed forest environment"- achieved through various types of timber, wildlife, and range management objectives (0.9%- 13,500 acres);

- grassland management for the production of cattle- achieved mainly through range and wildlife management objectives (0.9%- 13,000 acres); and

- those areas temporarily managed for the potential of being designated as a "special area" other than wilderness- such areas "reflect public issues or management concerns for protection of unusual environmental, recreational, cultural, and historical resources and for areas valuable for scientific or educational studies-includes candidate areas for national river status" (0.8%- 12,600 acres) (U.S. Forest Service 1986, 1998; Eberly, in. litt., February 1999).

Most of the management prescriptions outlined above involving timber and wildlife management also include the following additional objectives within the various landtype associations:

- woodland habitat in the 0-9 year age class;

- woodland habitat in old growth condition;

- ☞ woodland habitat in oak and oak-pine types over 50 years of age;
- ☞ woodland habitats in pole and saw timber size classes with crown closure over 80%;
- ☞ 25-35% (40-50%) of the sawtimber component of the woodland in oak, oak-pine, and pine that exhibits a condition of 20-30% forbs, grass, and shrub ground cover;
- ☞ woodland habitat in oak type over 50 years of age with a dense understory;
- ☞ open and semi-open habitats;
- ☞ permanent water sources per square mile; and
- ☞ recommended numbers of cavity tree and snag objectives (U.S. Forest Service 1986).

Recommended percentages for each objective listed above is based on several factors associated with each landtype association (U.S. Forest Service 1986). Timber management objectives are accomplished through timber stand improvement activities (e.g., thinning, salvage operations) (46%), uneven-aged harvest (34%), and even-aged harvest (20 %) (U.S. Forest Service 1998).

Specific proposed activities involve various timber management activities including:

- ☞ timber harvest (both even-aged and uneven-aged management);
- ☞ salvage (damage caused by wind storms, tornadoes, floods, and lighting or human induced wild fires) and firewood sales;
- ☞ timber stand improvement via thinning;
- ☞ tree plantings and routine creation/maintenance of small clearings to benefit wildlife;
- ☞ removal of hazard trees that are potentially injurious to human health and safety;
- ☞ the removal of trees associated with the construction and maintenance of roads and utility corridors; and
- ☞ and the felling of occasional trees for fish structures.

Other activities under the scope of the proposed action include:

- ☞ the construction and maintenance of recreation areas (i.e., campgrounds; picnic areas; and hiking, horseback riding, motor bike, and all-terrain vehicle trails);

- ☞ range management/grazing and associated treatments for forage improvements (e.g., application of fertilizers; grass seeding; prescribed fires) or converting pastures from cool to warm season species;

- ☞ pesticide and herbicide applications; prescribed fires and associated fireline construction;

- ☞ soil and water resource management (mostly water barring and other soil erosion control operations);

- ☞ the creation of brush piles for small and non-game species;

- ☞ the prospecting and extraction of minerals; and

- ☞ special use permits primarily involving the construction and maintenance of utility rights-of-way or road access to private lands adjoining Forest Service land.

Environmental baseline

The MTNF encompasses 1,493,198 acres and is comprised of seven Ranger Districts (District) in 29 Missouri counties. Six of the seven districts are south of the Missouri River in the southern, south central, southeastern, and southwestern portions of the state. The Cedar Creek District is the sole district located north of the Missouri River. The Doniphan/Eleven Point District embodies 331,441 acres in Carter, Oregon, Ripley, and Shannon counties. The Ava/Cassville/Willow Springs District consists of 314,720 acres scattered in Barry, Christian, Douglas, Howell, Ozark, Stone, and Taney counties. The Potosi/Fredericktown District embraces 282,196 acres in portions of Bollinger, Crawford, Iron, Madison, Reynolds, St. Francois, Ste. Genevieve, and Washington counties. Approximately 197,237 acres within parts of Laclede, Phelps, Pulaski, Texas, and Wright counties are encompassed within the Houston/Rolla District. The Salem District contains 193,494 acres and includes land in Crawford, Dent, Iron, Reynolds, and Shannon counties. The Poplar Bluff District is comprised of 156,430 acres throughout portions of Butler, Carter, and Wayne counties. The smallest district, Cedar Creek, consists of 15,270 acres within parts of Boone and Callaway counties.

Numerous topographical, geological, climatological, ecological, and evolutionary factors and features outline the landscape of the MTNF. The Forest is characterized by three distinct geological areas. The Cedar Creek District in the extreme northern portion of the Forest is where geological surface materials consist of glacial till formed following the recession of the Kansas glaciation. Kansas glacial till and the Loveland Peoria Loess of the Wisconsin age cover portions of the Salem Plateau and the Dissected Till Plains (McNab and Avers 1994).

The majority of the MTNF has Ordovician and Cambrian-aged sedimentary surface material consisting of cherty dolomites and sandstones. Elsewhere, there are areas where younger Mississippian limestone is present on ridgetops. The Mississippian formation is found predominantly in the extreme western sections of the Forest. In the eastern portion of the Forest,

the St. Francois Mountains stand apart by virtue of the Precambrian igneous rocks which are exposed. In some areas, they occur only at higher elevations, and rocks of Cambrian age occupy valley floors. The forest landscape is deeply dissected, with smaller areas of gently rolling landscapes and small plains on upland plateau remnants. Geological structure is abundant. Forest-wide, the thickness of the residuum varies from less than 1 foot to around 100 feet. A thin mantle of loess caps the residuum on the higher and more flattened ridges. Elsewhere the loess has been eroded. Across the Forest, elevations above sea level range from 350 to 1450 feet. A major portion of the MTNF is part of the Ozark Highlands (McNab and Avers 1994).

The Missouri Ozarks are characterized by a well represented karst topography, with well-eroded rolling hills, deep hollows, springs, caves, sinkholes, losing streams, natural bridges, and tunnels. Over 5,000 caves have been identified throughout the state. Of these, 416 have been documented on the MTNF and range from small, shallow rock shelters to complex caves with over 1 mile of passage. Although caves can be found on all National Forest districts, they are especially prevalent within the Ozark and Ozark Border Natural Divisions as described by Thom and Wilson (1980). Many of the forest's caves have permanent streams, but others are completely dry (U.S. Forest Service 1998).

Parts of the MTNF are found within the glaciated plains, Ozark, and Ozark border natural divisions of Missouri (Thom and Wilson 1980). By far, the largest acreage of the MTNF falls within the Ozark natural division and encompasses portions of the White River, Lower Ozark, St. Francois Mountains, and Upper Ozark subdivisions. All districts south of the Missouri River fall within the Ozark Natural Division. This division is a large, unglaciated region of greater relief and elevation than the surrounding areas.

Geologically, the Ozarks are one of the oldest regions in the United States and it encompasses nearly 40 % of the state. It is characterized by thin, often stony, residual soils, with loess being very thin or absent. Elevation above sea level ranges from about 400 feet to almost 1,800 feet, and local relief of 300 or more feet is not uncommon. Topography ranges from being very steep to nearly level and the area is characterized by numerous caves, springs, and bluffs. Streams are high gradient, clear-flowing, and have numerous meanders. Limestone and dolomite of Ordovician age underlie most of the area, but sandstone, shale, chert, and igneous rocks also occur. Bedrock is commonly exposed along streams and ridges. Deciduous, pine-oak, and pine forests were the predominant vegetation in presettlement times. Glades are common where bedrock surfaces and calcareous wet meadows (often termed "fens") with distinct plant communities are characteristic along many of the streams.

Extensive areas of prairie and savanna historically existed in the Springfield Plateau subsection while isolated areas occurred elsewhere. Currently, scattered remnant stands of prairie and especially savannahs are being managed and restored by the Forest Service, the Missouri Department of Natural Resources, and the Nature Conservancy throughout the Ozark Division. Bottomland deciduous forest and gravel bar communities are common along many Ozarkian streams. Karst features are common throughout the division except for the St. Francois

Mountains subsection. Geologically the Ozark Division is part of an ancient uplifted plain that has long been exposed to the dissecting action of its streams. The great age and physiographic diversity of the Ozarks make it the region of greatest diversity in Missouri with a distinct biota including numerous endemic plants and animals. The six subsections of the Ozark Division are defined by geologic history, stream drainages, soils, characteristic flora and fauna, and presettlement vegetation (Thom and Wilson 1980).

The Cedar Creek District of the MTNF encompasses portions of the Ozark Border and Glaciated Plains natural divisions (Thom and Wilson 1980). The Ozark Border Natural Division is characterized by: 1) rugged, highly dissected hills with deep, relatively productive soils, 2) sandstone cliffs, limestone cliffs, and pinnacles above major rivers, 3) caves, sinkholes, springs, and bluffs, and 4) rolling hills, gently sloping ridgetops, and valley bottoms scattered throughout. This section is drained by streams flowing into the Missouri River. Although this division shares many characteristics with the Ozark Natural Division and is often lumped physiographically with part of the Ozark Plateau Province (Fenneman 1938), it serves as transition zone between the Ozarks and the Glaciated Plains natural divisions.

The Glaciated Plains Natural Division is characterized by soils and topography that resulted from the influence of the Kansan stage of Pleistocene glaciation. Soils were formed from loess, glacial till, or alluvium (Thom and Wilson 1980). Prior to presettlement, about 55% of the division was covered with upland deciduous forest, while the remaining 45% was comprised of native tall grass prairie. Much of the Cedar Creek District is covered with deciduous forest but pasture, glades, and cedar thickets are scattered throughout. Bottomland timber and floodplain habitat exist along the larger streams that dissect and drain the division.

About 89% of the MTNF is covered with forest and the remaining 11% is in open-land habitats. The major forest type is oak-hickory that covers about 66% of the MTNF. Another 15% is oak-pine, 9% is shortleaf pine, with other forest types combined encompassing the remaining 10%.

Age composition of trees on the MTNF in descending order of magnitude are:

- 50 years old or older (72%: 956,841 acres- this includes 12% or 159,474 acres of trees 90 years old or older- old growth);
- 0-9 years old (11%: 146,184 acres);
- 20-49 years old (10%: 132,895 acres); and
- 10-19 years old (7%: 93,026 acres).

Water is abundant throughout the MTNF and there are currently about 3,500 acres of permanent streams, rivers, lakes, and ponds scattered throughout the Forest. Additionally, the abundant karst topography has resulted in the formation of 500 perennial springs, some of which have the

largest volume output of any springs in the United States (Vineyard and Feder 1974).

Each district of the MTNF is within easy driving distance of major metropolitan areas and provides various types of recreational opportunities. In addition to other recreational activities, Table Rock Lake and the adjacent Roaring River State Park provide numerous fishing opportunities for visitors to Branson and Springfield. Major rivers or streams within the Houston/Rolla District include the Gasconade and Big Piney Rivers, and Roubidoux Creek. This district is near the cities of Houston, Rolla, Waynesville, St. Robert, and borders the Fort Leonard Wood Military Installation. Montauk State Park is also nearby.

Portions of Huzzah Creek flow through the Salem District and this district is adjacent to the Current River and the Ozark National Scenic Riverways. The towns of Salem and Steelville are within easy driving distance of these areas. The Doniphan/Eleven Point District is not only the largest district of the MTNF in acreage (331,441), but is also one of the most scenic areas in North America. Centered around the small towns of Winona, Alton, Doniphan, and Van Buren, this district encompasses portions of the Current and Eleven Point rivers that include parts of the Ozarks National Scenic Riverways and the Eleven Point National Scenic River. An area with rich biological diversity, the area is home to some of the largest springs (in volume of output) in the United States and is adjacent to Big Spring State Park. Recreational activities (especially canoeing) on the Current and Eleven Point rivers provide numerous jobs to local residents.

The Poplar Bluff District provides easy access to Lake Wappapello, the Black and St. Francis rivers, and Cane Creek. The district is adjacent to Poplar Bluff as well as Lake Wappapello State Park and the Service's Mingo National Wildlife Refuge. The Fredericktown District embodies parts of the St. Francis and Twelve Mile rivers, and it is within easy driving distance from Fredericktown, Ironton, Farmington, and St. Louis. It is also adjacent to some of the most picturesque state parks in Missouri (i.e., Elephant Rock, Tom Sauk).

Portions of Curtois Creek and the headwaters of the Big River flow through the Potosi District and are near the small towns of Potosi and Centerville. Johnson Shut-Ins State Park is within easy driving distance of the district. The Cedar Creek district drains sections of Cedar Creek which is a tributary to the nearby Missouri River. This district is near Rock Bridge Memorial State Park and provides numerous recreational opportunities to residents of Columbia, Ashland, and Fulton. In addition to the state parks mentioned above, all districts of the MTNF are within easy access to numerous MDC Conservation Areas, and a few state forests and The Nature Conservancy preserves.

The thousands of acres of forest and the numerous rivers, streams, ponds, hiking trails, horseback riding trails, picnic grounds, and camping facilities on the MTNF provide recreational opportunities for thousands of visitors a year. Unlimited opportunities exist for hunting, fishing, hiking, camping, canoeing, boating, swimming, wildlife photography, bird watching, horseback riding, and picnicking. In a 1997 study of recreational use on the MTNF, hours of use were estimated for the following activities (in descending order of frequency):

- camping (4,879,044);
- auto travel (4,853,268);
- hunting (3,321,888);
- boating and canoeing (2,695,608);
- swimming (1,775,064);
- fishing (1,678,332);
- miscellaneous- includes nature study, bird watching, outdoor games, etc. (1,578,876);
- hiking (1,129,524);
- gathering- includes mushrooms, nuts, and wild berries (843,540); and
- biking (25, 416).

Combined, a total of 26,683,176 hours were expended by visitors to the MTNF in 1997 to enjoy the numerous, available recreational opportunities (Forest Service statistics provided by Eberly, in. litt., February 1999).

Past management and cultural practices influencing the environmental baseline

Past management and cultural practices of inhabitants using land within the boundaries of the MTNF since presettlement times have greatly influenced the current condition of Missouri's forests, prairies, glades, savannahs, waters, and other natural communities. Although concentrating primarily on the potential impact of historical land use changes on stream disturbance in the Ozark Plateaus, Jacobson and Primm's (1997) analysis provides an excellent summary of factors that have influenced the current condition of Missouri's landscape throughout the state.

Missouri's landscape today is totally different than what was observed by Schoolcraft when he traveled across the state in 1818 and 1819 (Schoolcraft 1819, 1821; Ladd 1991). Much of the forests were savanna-like in appearance, were much more open than they are now, and had a graminoid understory. Nelson (1985) estimated that as many as 13 million acres of savanna occurred in Missouri prior to settlement. The openness of Missouri's woodlands observed by Schoolcraft was maintained due to the frequent use of fire by Native Americans (Ladd 1991) who used this management technique to improve grazing habitat for big game, to aid in hunting, or to harass enemies (Barrett, 1980). By examining the fire scars of aged cedars and post oaks, Guyette & McGinnes (1982), and Guyette & Cutter (1991), determined that fires recurred on the average of 3.2 years from 1730 to settlement in the 1830's. After settlement, however, fire

frequency decreased to an average of one fire every 22 years. The suppression of fires following settlement had such an effect on the landscape that Marbut (1914) commented that large, "treeless grassy plains" completely disappeared within 30 years following the Civil War. Sauer (1920) noted that the combination of fire suppression, timber cutting, and over grazing caused open hills with a grass understory to become nearly extinct.

Most of the Ozarks were cut following settlement, with the peak occurring between 1880 and 1920 (Jacobson and Primm 1997). Since 1920, many of the areas cut over in the Ozarks have regrown to form extensive stands of mature, primarily oak-hickory forests. This is supported by forestry inventory data which indicates that the percent forest cover and sawtimber volume in the Missouri Ozarks increased significantly between 1972 and 1989 (Spencer *et al.* 1992; Hansen *et al.* 1992). Additionally, the continued suppression of fires, however, has contributed to a forest that is much less open than occurred prior to settlement (Ladd 1991).

Specific proposed actions implemented from the LRMP that affect the environment

The following programs (in average number of acres managed annually in the last 10 or five years and in decreasing order of abundance) summarize the various specific proposed actions implemented from the LRMP (as identified by U.S. Forest Service 1998):

Timber harvest/ management

Timber sales, which include both regeneration cuts and salvage and firewood sales, is one of the primary management activities which alters and/or disturbs the greatest acreage of forest habitat on the MTNF. Between 1986 and 1997, the average annual harvest of timber on the MTNF was 18,215 acres and within the last 5 years, the Forest Service has averaged the harvest of 18,100 acres of timber annually. Of these, 8,291 acres (46%) involved thinning, salvage, and miscellaneous operations (e.g., firewood permits); 6,167 acres (34%) involved uneven-aged management (i.e., group selection, single tree selection and single tree selection with groups harvest techniques; and 3,642 acres (20%) involved even-aged management (i.e., shelterwood, clearcut, and seedtree harvest techniques).

Within the last five years, the following annual average acreage of uneven-aged management harvest were employed on the MTNF (in descending order of abundance): group selection with improvement (2,813), uneven-aged improvement (2,060), group selection (673), and individual tree selection (383) (Eberly, in. litt., February, 1999). Within the last five years, the following annual average acreage of even-aged harvest were employed on the MTNF (in descending order of abundance): shelterwood (1,810), clearcut (1,034), and seedtree (798). Timber harvest on the Cedar Creek District is restricted to uneven-aged management using single tree selection or fire-wood thinning, and the annual harvest within this unit is approximately 75-125 acres (U.S. Forest Service 1998).

The MTNF has averaged about 59 million board feet of commercial timber each year since 1986, ranging from a high of 73 million board feet in 1987 to a low of 48.6 million board feet in 1990. An average of approximately 9,800 acres of reforestation via natural regeneration have been

accomplished per year since 1986, and timber stand improvements have been conducted on an average of 3,750 acres per year in the past 10 years. Reforestation by natural regeneration is accomplished on an average of 9,800 acres per year and about 3,750 acres per year are dedicated to timber stand improvement (i.e., releasing young trees by removing competing vegetation).

Prescribed fires

An average of 7,100 to 13,000 (an average of 9,515 acres in the last five years) acres are managed annually through the use of prescribed fires. Prescribed fires are used to create, maintain, or improve wildlife habitat, to reduce hazardous fuels, and is an important tool in restoring and managing pine and oak/pine savannahs, glades, prairies, native grasslands, and wildlife openings.

Wildlife management

In addition to the use of prescribed fires as mentioned above to improve an annual average of 9,000 acres of wildlife habitat, other activities are employed to benefit fish and wildlife. These include tree planting in riparian corridors, the construction of ponds or waterholes, brushhogging, planting of food plots, converting non-native fescue to native warm-season grasses, seeding of native legumes, fish stocking, lake fertilization, and fish shelters. An average of an additional 660 acres of habitat improvement work per year is used to directly benefit threatened and endangered species.

Wildfire (non-prescribed)

The deliberate or accidental setting of fires by forest visitors or lightning results in the impact to and annual average of approximately 4,500 acres per year. Although such fires may create habitat for wildlife and plants, they can also negatively impact the flora and fauna of the Forest if ignited during the growing season.

Land exchanges

Land acquisition of private property and exchanges for the same account for an annual average of 3, 930 acres per year. An annual average of 2,800 acres involve land acquisition, and 1,130 acres involve exchange of Forest Service land into private ownership.

Range management

Currently, 51,325 acres of open land are available for grazing. Of this acreage, approximately 19,500 acres per year are managed as allotments for cattle grazing and an estimated 2,000 acres per year are treated for forage improvement by prescribed burning, seeding, converting pastures from cool to native warm season grasses, and through the direct application of lime and fertilizers.

Soil and water resource management

Within the last five years, an annual of average of approximately 154 acres have been treated to provide benefits to soil and water resources. Such treatments include the waterbarring of roads and trail sections to reduce soil erosion, cleaning of garbage dumps, revegetation of bottomland

hardwoods by planting trees in old fields within riparian corridors, streambank stabilization procedures to halt soil erosion, the elimination and revegetation of illegal ATV trails, and the protection of riparian areas through the designation of filter strips which prevent sediment run off into streams and springs that could be potentially displaced during harvest operations, timber stand improvement activities, prescribed fires, and road construction or repair.

Pesticide use

The use of pesticides on the MTNF has decreased drastically within the last 12 years, and there has been no aerial application of herbicides or insecticides on the MTNF since the late 1960's. From 1986-89, the average annual application rate on the Forest was approximately 6,850 acres. Use dropped to an average of 860 acres per year between 1991 and 1995. Within the last five years, the average has decreased even further to 350 acres per year and the annual average was 120 acres in 1997 and 1998. Between 1986 and 1990, herbicides were mainly used for the release of young pines (i.e., by controlling competing vegetation), site preparation, right-of-way maintenance, and wildlife habitat improvement. Herbicide use currently is restricted to noxious weed control, conversion of non-native fescue grasses to native, warm-season species, utility and railroad right-of-way maintenance and the control of poison ivy around administrative and recreational sites.

Herbicides currently in use for utility right-of-way maintenance are Glyphosate (*Accord*), Triclopyr (*Garlon 3A, Garlon 4*), and Imazapyr (*Chopper*). Glyphosate (*Roundup, Rodeo, Accord*) is used around buildings, for noxious weed control, and for fescue control. Railroad right-of-ways are maintained with Diruon/Sulfometuron Methyl. Chemicals are applied to individual, target plants. The aerial application of herbicides or insecticides is prohibited on the MTNF, "unless it is has been approved by the Forest Supervisor and documented as the only environmentally sound and biologically effective method practicable" (U.S. Forest Service 1986, 1998).

Mineral exploration and extraction

Mineral production on the MTNF includes the removal of lead, copper, zinc, and silver, with lead being the largest commodity extracted. In 1996, the MTNF estimated that over half of all the lead mined in the United States originated from ore bodies located underneath the Forest. The main lead deposit underlying the MTNF is within the Viburnum trend in the Salem and Potosi Districts. Currently, there are 36 mineral leases, six prospecting permits, and seven prospecting permit applications filed with the Bureau of Land Management (BLM) who has oversight authority for all mineral leases. Mineral prospecting and development involves site preparations and associated activities with exploratory drilling.

Note: because mineral extraction associated with current ongoing leases involves numerous complex issues (e.g., BLM has oversight authority, mineral extraction is accomplished from mining operations on private property outside Forest Service boundaries, etc.), this opinion covers only those activities connected with exploratory and developmental drilling conducted from the surface of the MTNF (includes surface

disturbance associated with site preparation and subsurface drilling operations). Further consultation is necessary to assess the impacts of mineral extraction on federally-listed species that could be impacted by the 36 leases currently in operation.

Exploratory drilling impacts an average of approximately 20 surface acres a year on the MTNF. Associated activities include the construction of temporary roads when necessary to exploratory drill sites, site preparation involving the clearing of ca. 1/4 acre of vegetation, the insertion of surface casings, and above ground drilling operations which are conducted from standard truck-mounted rotary and diamond core drill rigs. Subsurface disturbance involves case and core drilling to a depth of 2,200 to 2,300 feet. Water, a biodegradable foaming agent, and an expanding clay may be used during drilling operations to cool drill bits and prevent the collapse of the sides of drill holes. Following drilling, all holes are plugged with a commercial grout, and drill sites and temporary access roads (if necessary) are reclaimed (Eberly, in litt. February 8, 1999).

Recreation management

The MTNF currently has 74 developed recreation areas that include campgrounds, picnic areas, and river and stream accesses. Approximately 740 miles of hiking and/or horseback riding trails, 20 miles of all-terrain vehicle trails, and 125 miles of a motor bike trail are also provided. Management and maintenance of these areas is primarily restricted to existing campgrounds, picnic sites and access roads, but does involve the removal of hazard trees, and the removal and trimming of trees within trail corridors.

Road construction and maintenance

Approximately 2,350 miles of road are maintained by the MTNF. In the past 10 years, only 1.5 miles of new permanent roads have been constructed. Temporary roads are constructed to provide access to exploratory drill sites and to timber management activities.

Special designated areas

Several areas on the MTNF are under special designation. Management on these areas outside of natural forces is either prohibited, requires approval by the Chief of the Forest Service, or is extremely limited. The MTNF contains seven federally-designated Wildernesses totaling 63,160 acres (in descending order based on total acreage)(U.S. Forest Service 1986, 1998):

- 1) Irish Wilderness in the Doniphan/Eleven Point District- 16,600 acres,
- 2) Hercules Glades Wilderness in the Ava District- 12,314 acres,
- 3) Bell Mountain Wilderness in the Potosi District- 8,777 acres,
- 4) Piney Creek Wilderness in Cassville District-7,927 acres,
- 5) Paddy Creek Wilderness in the Houston District- 6,728 acres,

- 6) Devil's Backbone Wilderness in the Willow Springs District- 6,595 acres, and

- 7) Rock Pile Mountain Wilderness in the Fredericktown District- 4,159 acres.

Other than prescribed fire on the Hercules Glades Wilderness to maintain the area's biological diverse glade community, and occasional trail maintenance, all other activities including motorized or mechanized vehicles or equipment are prohibited from all designated wilderness areas (U.S. Forest Service 1998).

An additional 1,040 acres of Irish Wilderness "excluded lands" adjacent to the Irish Wilderness on the Doniphan/Eleven Point District have been set aside for special designation. Initially this area was to be managed as a federally-designated wilderness area with the exception that mineral exploration was to be allowed. Due to the potential impact to the Irish Wilderness and the Eleven Point National Scenic River, exploratory drilling in the Doniphan/Eleven Point District area has been a source of considerable debate for several years. Although a permit for exploratory drilling had been issued for the "excluded lands" and a few holes were drilled under the permit, the time frame for accepting exploratory drilling permit applications for this area has since expired, and no further exploratory drilling is anticipated in this area. Consequently, exploratory drilling is now prohibited from the Irish Wilderness and adjacent "excluded lands" (Eberly, pers. commun. February 17, April 26, 1999)

Additionally, on October 26, 1998, the Doe Run Mining Company withdrew three new, one extension, and one old exploratory drilling permit applications outside of the Irish Wilderness and the excluded lands mentioned above, but within the Doniphan/Eleven Point District (Eberly, in litt. February 8; Eberly, pers. commun. April 26, 1999).

Approximately 44.4 miles encompassing 8,021 acres of the Eleven Point River has been designated as the Eleven Point National Scenic River in the Doniphan/Eleven Point District. Management within this area is restricted to habitat manipulation to benefit endangered and threatened species and unique natural communities; the removal of hazard trees to protect human safety; salvage operations to remove trees damaged by catastrophic events (e.g., windstorm, lightning strikes, wild fires, etc.); trail maintenance; and the maintenance or management of recreation sites (U.S. Forest Service 1998).

The Greer Spring Special Management Areas contains approximately 4,098 acres adjacent to the Eleven Point National Scenic River on the Doniphan/Eleven Point District. Management and habitat manipulation within this area includes: trail maintenance; maintenance of the two access roads to the area; the control of insects and/or disease; and the removal of hazard trees to protect human safety, and uneven-aged timber harvest using the single tree selection method when practical (U.S. Forest Service 1998).

Sixteen miles of the lower Current River within the Doniphan/Eleven Point District has been

designated as a Forest Special Area and consists of 2,040 acres. Within this area, the main management objective is to "protect and enhance the recreation experience of river users" (Forest Service 1998). Management within this area is restricted primarily to: habitat manipulation to benefit endangered and threatened species and unique natural communities; the removal of hazard trees to protect human safety; and salvage operations to remove trees damaged by catastrophic events (e.g., windstorm, lightning strikes, wild fires, etc.) (Forest Service 1998).

Seven rivers or creeks within the MTNF have been identified as candidates for inclusion in the National Wild and Scenic Rivers System: Big Piney River (~81.5 miles) in the Houston/Rolla District, Cedar Creek (~29 miles) in the Cedar Creek District, Curtois Creek (~18 miles) in the Potosi District, Gasconade River (~56 miles) in the Houston/Rolla District, Huzzah Creek (~28 miles) in the Salem District, St. Francis River (~17 miles) in the Poplar Bluff District, and the North Fork of the White River (~ 30 miles) in the Willow Springs Unit of the Ava./Cassville/Willow Springs District. The perpetuation of the "current condition" within a 0.25 mile zone along each side of candidate rivers/creeks is the primary management objective for waters so designated. When necessary to meet management objectives, only uneven-aged management is allowed within the zones identified.

Eighteen areas encompassing 5,824 acres on the MTNF have been designated as State Natural Areas. They range in size from 2 acres to almost 3,000 acres. The primary management objective for such areas is to perpetuate the special attributes and habitat features unique to each. Limited timber management and/or the use of prescribed fire may be necessary to maintain and perpetuate the attributes of each area.

Analysis of the species/critical habitat likely to be affected

This opinion considers the potential affects of the continued implementation of the LRMP of the MTNF on those species for which the Service concurs with the Forest Service are likely to be adversely affected. As previously discussed, these are the gray bat, bald eagle, Indiana bat, and Mead's milkweed. Because the Service has concurred with the Forest Service that continued implementation of the LRMP of the MTNF is not likely to adversely affect running buffalo clover (*Trifolium stoloniferum*) or the Tumbling Creek cavesnail (*Antrobia culveri*), and concluded that a no effect determination is appropriate for the Topeka shiner (*Notropis topeka*), Curtis' pearly mussel (*Epioblasma curtisi*), pink mucket pearly mussel (*Lampsilis abrupta*), and Hall's bulrush (*Schoenoplectus hallii*), these species will not be considered further in this opinion.

Gray bat

A. Species/habitat description/life history

Gray bats are medium sized with a wingspan of 10-11 inches, and are the largest *Myotis* species in the eastern United States. They have grayish-brown fur are the only *Myotis* species whose wing membrane connects to the ankle instead of the base of the first toe. Gray bats are a monotypic species that occupy a limited geographic range in limestone karst areas of the southeastern and central United States.

Gray bats migrate each year between winter and summer caves. Migration distances range from several miles to 200 miles (Clawson *et al.* 1992). Mating occurs at winter caves during September. After copulation, females enter hibernation but males and juveniles continue feeding for several weeks. By early November, most gray bats are hibernating. Adult females begin to emerge in late March, followed by juveniles and adult males. Females store sperm in the winter and become pregnant after emerging in the spring. A single offspring is born in late May or early June. Young become volant 20 to 25 days after birth.

Gray bats have very specific cave requirements (Tuttle 1974, 1979). As a result, less than five percent of available caves are suitable. Different caves are utilized during summer and winter, and multiple caves may used by a single colony during the summer (Tuttle 1974, 1976a). Winter caves must be very cold with a range in temperature between 42° and 52 °F. Winter caves are deep with vertical walls and act as cold air traps (U.S. Fish and Wildlife Service 1982). Summer caves must be warm (55°-77 °F), or with restricted rooms that can trap the body heat of roosting bats. Migrating gray bats appear to travel in groups and may stop for several days in "transient" caves while migrating in the spring and fall. Mortality during migration, especially for juveniles, is not uncommon (Tuttle, 1976b). Annual survival rates are about 60% (Clawson *et al.* 1992).

Summer caves used by females are termed "maternity" caves and are located close to rivers or lakes where the bats feed. Most males, non-reproductively active females, and juveniles inhabit non-maternity caves during the summer. Unlike Indiana bats, gray bat females do not become reproductively active until their second year of life. Large maternity colonies usually have 10,000-50,000 bats. Typically, summer caves are within 0.6 miles of a river or lake. Most foraging occurs within seven miles of roosts (LaVal *et al.* 1977), but gray bats may range up to 12 miles nightly. Gray bats are insectivorous and prefer to forage over water (Tuttle 1974). Because gray bats forage over water, their diet consists primarily of emergent forms of aquatic insects. Individual bats are loyal to their colony home range, but may use several caves within the home range (3D/International Inc. 1996). Gray bats must deposit fat for survival during winter hibernation. This is accomplished in the fall immediately prior to entering hibernation (Tuttle 1976b). In July and August, adult females and their young rejoin the bachelor males and non-reproductive females (Clawson *et al.* 1992). This group migrates to the hibernacula between August and October.

B. Status and distribution

The gray bat was listed as federally endangered on April 28, 1976 *(Federal Register* 41:17740). No Critical Habitat has been designated for this species. The gray bat recovery plan was published on July 1, 1982, and outlines the following broad recovery actions: (1) acquire and protect important caves; (2) control foraging habitat destruction; (3) educate the public and private cave owners; and (4) continue research and monitoring of populations.

Gray bats are a monotypic species that occupy a limited geographic range in limestone karst areas of the southeastern United States. Populations are found mainly in Alabama, northern Arkansas, Kentucky, Missouri, and Tennessee. Small populations inhabit northwestern Florida, western

Georgia, and southeastern Kansas, southern Indiana, southern and southwestern Illinois, northeastern Oklahoma, northeastern Mississippi, western Virginia, and possibly western North Carolina.

Historically, individual hibernating populations of gray bats contained 100,000 to 1.5 million or more bats (U.S. Fish and Wildlife Service 1982). About 95 percent of the bats hibernated in only nine caves with more than one-half in a single cave.

Estimation of range-wide gray bat population size is difficult (U.S. Fish and Wildlife Service 1982). Censussing of the nine major hibernacula between 1977 and 1982 resulted in a total population of 1,575,00 bats. Nineteen percent (300,000) of the population occurred in the three major hibernacula located in Missouri. However, censussing for the species was not standardized until the 1980's (Clawson *et al.* 1992). In the mid-1980's, the total population at major hibernacula in Missouri was estimated to be around 500,000, while the number of gray bats counted at maternity sites was approximately 500,000+ (Clawson *et al.* 1992). The count obtained at maternity sites can only be viewed as a rough estimate, however, because observations were not made the same year and such calculations do not take into account the annual fluctuations that occur at individual caves.

Precipitous declines occurred in gray bat populations starting in the early 1960's. By 1976, Tuttle (1979) estimated that gray bat populations had declined 76% in 22 Alabama and Tennessee summer colonies from maximum levels recorded prior to 1968. Reductions in Missouri maternity caves paralleled the apparent decrease in Alabama and Tennessee declining by 72% by 1978 (U.S. Fish and Wildlife Service 1982). In Kentucky, bat populations declined 88% over the same period.

The U.S. Fish and Wildlife Service (1982), cited five primary causes for the decline in gray bat populations: 1) human disturbance to the bats, 2) human disturbance to the environment, 3) cave destruction from impoundments, 4) cave commercialization, and 5) natural sources of mortality. Human disturbance between late May and mid-July at maternity caves, and between mid-August and late April at hibernacula is especially harmful. Flightless young are vulnerable to disturbance during the spring and early summer, and hibernating colonies are easily aroused by disturbances during winter. Tuttle (1979) linked much of the decline in the Alabama and Tennessee colonies to human disturbance. Exposure to toxins, including pesticides and their by-products, such as dieldrin (Clark *et al.* 1978, Clawson 1984) have caused gray bat mortalities, and may also be an important threat to survival and recovery of gray bat populations.

Since the 1980's, gray bat populations rangewide are stable or increasing (Rick Clawson, Missouri Department of Conservation, pers. comm.). This is supported by McGimsey and Johnson (1994) who surveyed 66 Missouri caves historically used by gray bats but ones which had not been surveyed in recent years prior to their study. They confirmed the presence of gray bats in 22 caves; six caves were found to serve as maternity sites, 12 were transient use sites, and the type of use was undeterminable for four caves. Approximately 64,790 gray bats were observed at

maternity sites, 7,683 were counted at transient sites, and 16,150 were noted in caves were use (i.e., maternity or transient) was undeterminable. The fact that a total of 88,623 bats were counted in 22 historical caves that had not been surveyed in recent years provides additional evidence that this species is continuing to rebound in Missouri. Although the reasons for this turn-around have not been determined, it is likely due to increased protection measures provided for many gray bat caves in recent years. Some caves have been acquired and protected by the installation of new and/or improved cave gates . Also, use of many persistent pesticides and their byproducts (DDT, DDD, DDE, heptachlor epoxide etc.), and other liophilic toxins (e.g., PCBs) was eliminated or severely curtailed after the 1970's.

C. Status of the species within the action area

There are approximately125 caves in Missouri where this species has been documented, and of these, 14 occur on the MTNF. However, the species has been documented in only 11 Forest Service caves within the last 25 years (Missouri Department of Conservation 1997; Forest Service 1998). Of these, six have been used as maternity caves and five have been used as transient sites. Gray bats have not been recorded in two caves since 1980 and one since 1976. Because censussing of gray bats in non-priority 1 maternity caves and hibernacula in Missouri (including those on the MTNF) have not been conducted on a regular, systematic basis (Missouri Department of Conservation 1997; Forest Service 1998), and population numbers fluctuate widely from year to year, it is extremely difficult to obtain an accurate picture of trends of this species for all occupied caves on the National Forest. Nonetheless, sufficient information exists to outline trends for seven caves.

The species appears to be increasing dramatically at four caves. Estimates of gray bats at maternity cave ORE-G1 have increased from 7,000 bats in 1978 to 15,000 individuals in 1998; from 124 bats at maternity cave ORE-G3 in 1979 to 13,600 individuals in 1997; from 1,400 individuals at maternity cave ORE-G5 in 1980 to 4,250 bats in 1990; and from 5,000 bats at maternity cave OZA-G1 in 1979 to 27,200 individuals in 1994. Data for maternity cave OZA-G1 should be carefully analyzed, however, as the species actually decreased from a high of 33,250 individuals in 1983 to 16,450 bats in 1991, before rebounding to the 27,200 recorded in 1994.

Recent estimates suggest that gray bats are decreasing at two caves: at maternity cave ORE-G5, the population increased from 7,500 bats in 1981 to 9,450 individuals in 1988, but then decreased to 7,750 individuals in 1990 and 3,400 bats in 1994. Similarly, at maternity cave REY-G1, the population increased from 7,000 bats in 1978 to 13,000 in 1983, but then decreased to 6,850 individuals in 1989 and 4,800 bats in 1991. Gray bats have apparently disappeared entirely from one transient cave, CFD-G1. In 1976, 7,000 bats were estimated but no individuals were observed when this cave was surveyed in 1994.

As with studies conducted by McGimsey and Johnson (1994) for other areas in Missouri, there is also recent data that suggest that gray bats are possibly using areas on the MTNF where the species had previously never been recorded. In late April/early May 1997, 500 gray bats were observed using cave PUL-GI (Missouri Department of Conservation 1997; Forest Service 1998).

While it is not yet known whether these individuals were using the cave as a maternity or transient site, the observations may provide further evidence that gray bat populations are increasing in some areas of the MTNF and expanding into new caves.

Gray bats apparently use cave MAD-1 solely as a transient site. In 1980, 200 individuals were observed but the species has not been documented there since. The exact status of gray bats in cave ORE-G2 is not yet fully understood. In 1994, 12 gray bats were observed using this cave as a transient site. Recent studies by members of the Cave Research Foundation, however, suggest that this cave may be also used as a hibernaculum and as a maternity site. In 1997, they estimated that 10,000 gray bats were using this cave as a maternity site but also noted that probably "100's" of individuals occupied the site as a hibernaculum (Forest Service 1998).

The four protected caves on the MTNF were gated during the following years: OZA-G1 (1973, but repaired and locked in 1994); ORE-G1 (1994); ORE-G6 (1994); and REY-G1 (1996) (Houf, pers. commun., February 23, 1999). Because of the manner in which gray bat caves throughout the state have been surveyed (i.e. not all caves surveyed in the same year, nor at the same regularity- Forest Service 1998), including those on the MTNF, and because population numbers have fluctuated widely during those years when surveys were conducted, it is extremely difficult to estimate the total population on the National Forest. Nonetheless, the data that does exist suggests that the maximum population is between 50,000 and 60,000 individuals. This would constitute about 12-15% of Missouri's population and about 3-4% of the population in the United States.

D. Effects of the action (direct and indirect effects)

Direct effects

The main potential direct effects to the gray bat would be human disturbance to hibernating bats during the winter season or to maternity colonies during the summer. Because only four of the 14 caves used by gray bats on the MTNF are gated, human disturbance is possible. The Forest Service (1998) concluded that "human disturbance at maternity caves and hibernacula is probably the major cause of past declines in specific gray bat caves on the forest." Additionally, there have been instances of even the gated and fenced caves on the MTNF of being vandalized and allowing entrance to gray bat sites (Forest Service 1998).

Additional analysis of the trend in one gated cave on the MTNF may provide further evidence that human disturbance of gray bat caves has been a problem on the Forest, and has contributed to the decline of the species there. Cave OZA-G1 was gated in 1973 and numbers fluctuated from 5,000 in 1979; to 33,250 in 1983; to 19,200 in 1989; to 16,450 in 1991. After this cave's gate was repaired and locked in 1994, however, the population increased to 27,200 bats (Forest Service 1998).

The largest population decline observed in any cave on the MTNF occurred between 1990 and 1994 in ORE-G5 when gray bat numbers decreased by 4,350 individuals, or an average of 870

bats per year. Although there is an additional possibility that the drop in numbers in ORE-G5 was due to gray bats moving from ORE-G5 (which may have only been used as a transient site-Eberly in. litt. May 24, 1999) to ORE-G3, which exhibited a dramatic increase in numbers between 1979 and 1997, there is no solid evidence that such a shift in roosting between the two caves took place. Consequently, the possibility that the drop in numbers in ORE-G5 was due to human disturbance can not be ruled out. Disturbance of hibernating gray bats could cause them to arouse and exhaust stored fat reserves prematurely (Daan, 1973). While the Forest Service has been successful in protecting some of the gray bat caves on the MTNF by installing various protective measures, other caves remain unprotected and are subject to human disturbance by recreational cavers and other visitors.

The MTNF annually conducts prescribed fires on about 7,100-13,000 acres throughout the forest. Gray bats could be directly impacted from drifting smoke that enters the cave from adjacent burns. Smoke that comes in contact with gray bat could adversely impact the species due to smoke inhalation (Elder and Gunier, 1981).

Indirect effects

Indirect effects are defined as those that are caused by the proposed actions and are later in time, but still are reasonably certain to occur (50 CFR 402.02). The main potential indirect effects to the gray bat on the MTNF would be; 1) loss of the species' prey base due to the degradation of water quality of streams, rivers, and lakes that could negatively impact the emergence of the aquatic insects that the species forages on, and 2) loss of foraging habitat due to the alteration of riparian corridors over which the species forages.

The U.S. Geological Survey conducted an extensive water quality study of the Ozark Plateaus in Arkansas, Kansas, Missouri (including basins that cover National Forest land in most districts of the MTNF), and Oklahoma between 1992 and 1995, and concluded that the water quality was well within acceptable levels for several parameters established by EPA (Petersen *et al.* 1998). Sedimentation, however, was not included in their analysis.

The impacts of siltation on aquatic insects, as it relates to the production of prey items for gray bats, has not been thoroughly studied. Nonetheless, Tuttle (1979) noted that none of the five gray bat colonies that he studied whose population numbers remained stable between 1970 and 1976 foraged over heavily silted waterways. Contrary to conclusions stated by the Forest Service in their 1998 Biological Assessment, the Service believes that sedimentation from activities on the MTNF could potentially adversely impact streams, rivers, and lakes on the MTNF where the species forages, even if the standards and guidelines outlined in the LRMP for the National Forest are followed. Ground-disturbing forest management activities, such as some timber harvesting, road construction and maintenance, prescribed fires, overgrazing, ATV and motor bike use, and trampling from livestock have the potential for soil to move off site. The Service would predict, however, that potential adverse impacts from siltation is likely to be minimal because very little management is undertaken within riparian corridors, and standards and guidelines outlined in the LRMP for the MTNF provide recommendations that minimize soil erosion and maintain good

water quality. Nonetheless, sediment transport into aquatic systems from activities upslope of riparian corridors is possible.

E. Cumulative effects

Cumulative effects include the combined effects of any future State, local, or private actions that are reasonably certain to occur within the action area covered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA. Additionally, any future Federal, State, local, or private actions that are reasonably certain to occur in the action area, and which are considered in this biological opinion, will either be carried out by, or will require a permit from, the Forest Service; they will, therefore, require compliance with Section 7 of the ESA. Because the Service is not aware of any future State, local, or private actions that are reasonably certain to occur within the action area and which would not be subject to Forest Service Section 7 review, cumulative effects, as defined by the ESA, will not occur and will not be addressed further in this opinion.

F. Conclusion

After reviewing the current status of the gray bat; the environmental baseline for the action area; the effects of forest management and other activities on the MTNF (both direct and indirect); additional measures identified in the Forest Service's BA to assist in the protection, management, and recovery of the species; and any possible cumulative effects, it is the Service's biological opinion that forest management and other activities authorized, funded, or carried out by the MTNF through the implementation of the LRMP, are not likely to jeopardize the continued existence of the gray bat. Because critical habitat has not been designated for this species, none will be adversely affected by the continued implementation of the LRMP.

G. Incidental take statement

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act, prohibit the take of endangered and threatened species, respectively, without special exemption. Take is definded as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns, including breeding, feeding, or sheltering. Harass is defined the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of Section 7(b)(4) and Section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are **non-discretionary**, and must be undertaken by the Forest Service (MTNF) so that they become binding conditions of any grant or permit issue to an

applicant, as appropriate, for the exemption of Section 7(o)(2) to apply. The Forest Service (MTNF) has a continuing duty to regulate the activity covered by this incidental take statement. If the Forest Service (MTNF) (1) fails to assume and implement the terms and conditions, or (2) fails to require an applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of Section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Forest Service must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement [50 CFR § 402.14(i)(3)].

H. Amount or extent of incidental take anticipated

The Service anticipates that incidental take of gray bats may occur as a result of continued implementation of the LRMP on the MTNF due to human disturbance. Specifically, the Service anticipates that incidental take of gray bats may occur due to human disturbance at the four ungated caves where the gray bats have been documented during the last surveys conducted on the MTNF (i.e., 1994 and 1997): ORE-G2, ORE-G3, ORE-G5, and PUL-G1. Although incidental take in the form of harass and harm may occur in these four, ungated caves, the number of gray bats anticipated to be taken is difficult to estimate due to the manner that this species was surveyed on the MTNF and due to annual population fluctuations that occur for reasons that are still poorly understood. Nonetheless, there is evidence that human disturbance in ungated caves may have contributed to the decline of the species on the MTNF, and the Service anticipates that as many as 4,350 bats (the largest population decline observed between 1990 and 1994 in ORE-G5) was lost within a five-year period or an average of 870 bats per year.

Given that another ungated cave has shown a decrease in the numbers of gray bats in the past (i.e., ORE-G3), and others have only been censussed for one year, (i.e., MAD-G1 and PUL-G1), it is possible that additional bats would be taken due to human disturbance. Although the Service acknowledges that some of these caves are difficult to access and little human disturbance has been documented when visited by personnel of the MTNF (Forest Service 1998), an additional unquantifiable level of take of bats per year is anticipated. Consequently, the Service anticipates that a minimum of 870 bats may be taken in ungated caves on the MTNF due to human disturbance.

Additionally, the Service anticipates that an unquantifiable level of incidental take is possible due to: 1) adverse effects to bats due to smoke inhalation when smoke from prescribed fires drift into caves occupied by the species; and 2) loss of the bats' insect prey base due to siltation from various activities on the MTNF. However, the Service believes that the potential incidental take from smoke inhalation and the loss of the species' forage base is extremely remote.

I. Effect of the take

The Service has determined that the level of anticipated incidental take of gray bats is not likely to result in jeopardy to the species.

J. Reasonable and prudent measures

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize impacts of incidental take of gray bats on the MTNF:

- Discourage human visitation to MTNF gray bat caves with more than 500 gray bats within the last 10 years with proven techniques appropriate to each individual cave.

- Following the guidelines outlined in Clawson et al. (1992), conduct regular monitoring of the status of gray bats in all MTNF caves with documented populations of more than 500 gray bats within the last 10 years.

- Implement appropriate smoke management techniques to minimize potential smoke effects to occupied gray bat caves.

The Service believes that the reasonable and prudent measures outlined above will significantly reduce the impacts of incidental take of gray bats on the MTNF and that these measures are reasonable and fall within the Forest Service's responsibilities to conserve federally listed species as outlined in Sections 2(c)(1) and 7(a)(1) of the Act.

K. Terms and conditions

In order to be exempt from the prohibitions of section 9 of the Act, the Forest Service (MTNF) must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline the required reporting/monitoring requirements. These terms and conditions are non-discretionary.

In order to decrease human disturbance, the following is necessary:

- By January 2001, determine the appropriate protective measures for caves ORE-G2, ORE-G5, and ORE-G3 to minimize human visitation during periods of gray bat use. Such efforts must be coordinated with the Service, MDC, Bat Conservation International, and/or others, as appropriate.

- Implement protective measures in cooperation with the Service and MDC within 3 years after completion. Any protective measures implemented must be reviewed and approved by Service and MDC cave protection experts prior to construction.

- Provide an annual report to the Service's Columbia, Missouri Field Office and MDC cave/bat specialists by December 31 of each year. This report will include: a) results of any population monitoring completed that year, b) any documented human disturbance, c) identification of protective measures needed to protect ORE-G2, ORE-G5, and ORE-G3, d) completion of any protective measures (i.e., gate, signs, fences, etc.) installed, and f) any documented incidental take as a result of human disturbance in gray bat caves on the MTNF.

- ☞ If human disturbance is documented and results in the take of gray bats that exceed the level of incidental take listed above (> 870), reinitiation of formal consultation is required (see Reinitiation Notice below).

In order to meet cave monitoring requirements, it is necessary to:

- ☞ Coordinate with the Service and MDC to insure that occupied MTNF gray bat caves are regularly and consistently monitored by individuals experienced in identifying gray bats and their sign.

- ☞ Provide a schedule for monitoring to the Service's Columbia, Missouri, Ecological Services Field Office and MDC by December 31, 1999.

In order to minimize impacts to gray bats from prescribed fires, it is necessary to:

- ☞ Increase the area of old growth forest (old growth) around caves with current populations of gray bats to a minimum of 20 contiguous acres; this area will include the cave entrance, the area above any known cave passage, the foraging corridor from cave to nearest water source, and ridgetops/side slopes above the cave.

- ☞ Consider all occupied gray bat caves as smoke sensitive areas. Conduct any planned prescribed fire in the vicinity of occupied gray bat cave only when the following have been considered: wind direction, speed, mixing height and transport winds needed in burn planning and implementation to minimize smoke drifting toward or into occupied gray bat caves and to prevent any night-time smoke inversions around the cave.

- ☞ Prior to the employment of any prescribed fire, provide the Service's Columbia, Missouri Ecological Services Field Office with the opportunity to review burn plans that could potentially impact gray bats.

- ☞ Provide an annual report to the Service's Columbia, Missouri Field Office and MDC cave/bat specialists by December 31 of each year, on any documented case of a prescribed fire that behaved contrary to predicted movement patterns and which resulted in a confirmed adverse impact to roosting gray bats.

The Service believes that approximately 870 gray bats could be incidentally taken per year as a result of the proposed action (i.e., implementation of the LRMP on the MTNF). The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation (see Initiation Notice below) and review of the reasonable and prudent measures provided. In such an event, the Forest Service (MTNF) must immediately provide an explanation of the causes of the taking and participate with the Service in

reviewing the need for possible modification of the reasonable and prudent measures.

L. Conservation recommendations

Sections 2(c)(1) and 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purpose of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The Service recommends that the MTNF implement the following conservation measures for the benefit of the gray bat:

- Continue to monitor and document any significant soil movement as a result of various management activities undertaken by the Forest Service. Cooperate with other agencies and/or universities in ongoing or new studies which would help determine if activities on the MTNF contribute to sediment deposition into streams, rivers, and lakes. Cooperate in any studies regarding potential effects of excess sedimentation on aquatic insects on which the gray bat feeds. Provide monitoring results to the Service's Columbia, Missouri Ecological Services Field Office no later than December 31 of each year.

- In consultation with the Service and MDC, develop an educational brochure and slide program that includes information on: ways to minimize human disturbance to gray bat maternity colonies or hibernacula; the status of the species in the eastern United States, Missouri, and on the MTNF; various aspects of its life history and habitat requirements; the ecological benefits of bats, etc. When opportunities exist, work with adjacent cave owners, the general public, and other agencies to promote education and information about gray bats and their conservation.

- In consultation with the Service and MDC, conduct training for employees of the MTNF on bats (including gray bat) in the National Forest; training should include sections on bat identification, biology, habitat requirements, and sampling techniques; the proper training of MTNF biologists on bat identification and a reliable method for counting roosting bats will enable the Forest Service to monitor the status of this species independently of other agencies; such freedom should ensure that all caves are monitored during the same year and that counts are conducted in a regular and consistent fashion.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

Bald eagle

A. Species/habitat description/life history

The bald eagle is a large, powerful brown bird with a white head and tail. Young eagles are

mostly dark brown until four to six years of age and may be confused with the golden eagle. Bald eagles are the only sea eagles regularly occurring on the North American continent, and range from central Alaska and Canada to northern Mexico. Adult male birds weigh 8-10 pounds and may grow to 3 feet, head to tail; females may weigh up to 14 pounds and grow to 3.5 feet (Gerrard and Bortolotti 1988).

Bald eagles are strongly associated with aquatic environments throughout most of its range (Gerrard and Bortolitti 1988; Millar 1995), but will use upland areas when water is frozen over (Stenhof *et al.*, 1980). Nesting eagles are associated almost exclusively with lakes, rivers, or sea coasts (U.S. Fish and Wildlife Service 1983a) and are usually no farther than two miles from water (McEwan and Hirth 1979; Gerrard and Bortolotti 1988). Although fish predominate in the typical diet of eagles, many other types of prey are also taken, including waterfowl (Munro 1938; Swisher 1964; Griffin *et al.* 1982) and small mammals (Edwards 1969; Platt 1976), depending on location, time of year, and population cycles of prey species (Steenhof 1978; Millar 1995). Gizzard shad (*Dorosoma cepedianum*) has been identified as a major fish prey item in some areas (Southern 1963, 1964; Grewe 1966; Jonen 1973; Lish and Lewis 1975; Hopkins 1988; Martrell 1992). Lincer *et al.* (1979) also documented that carrion are also taken when available, especially in wintering areas.

Both nesting and wintering habitats must have adequate perching, roosting, and nesting sites, generally trees, and an adequate food base to support eagles. Nesting birds build their nests in mature trees, on cliffs, or rock outcrops where large trees are not available (U.S. Fish and Wildlife Service 1983a). Nest sites are usually in large trees along shorelines in relatively remote areas (Millar 1995) or where there is reduced human activity (Andrew and Mosher 1982). Outside the nesting season, bald eagles usually prefer areas away from human disturbance (Lish and Lewis 1975; Buehler *et al.* 1991), but are tolerant of limited activity in some situations (Stenhof 1978; Martell 1992). In some studies, however, human disturbance, especially of night roosts, can overburden the daily energy budget of wintering eagles causing a significant increase in physiological stress (Stalmaster and Newman 1978; Stalmaster and Gessaman 1984).

Generally, trees with diameter-at-breast height greater than 11 inches and within 100-600 feet of water are preferred perching sites (Vian 1971; Lish and Lewis 1975; Steenhof 1976, 1978). Eagles tend to roost on the tallest trees (> 63') (Lish and Lewis 1975; Stalmaster and Newman 1979). Where they occur throughout the range, cottonwood (*Populus deltoides*) trees are often selected over other trees for perching and roosting (Lish and Lewis 1975; Stenhof 1978; Osterfeld 1988). Larger more open-branching trees are also favored by wintering eagles for night roosts (Stenhof 1978). Sheltered timber stands are important as alternative night roosts during severe winter weather because of the thermal protection they provide (U.S. Fish and Wildlife Service 1983a; Osterfield 1988; Martrell 1992). This is probably less important, however, at lower latitudes within the species range where temperatures are less severe. Distance of communal night roosts from foraging areas varies between 0.5 and 17.8 miles (Stenhof 1978).

At this latitude, wintering birds typically occur between November 15 and March 1. Nest

initiation activities may begin as early as January with incubation and rearing of young from March through mid-May. Females lay one to three eggs depending on environmental conditions and the fitness of the female. Incubation lasts about 35 days, and young fledge 10-14 weeks after hatching. Most young fledge from June 1 to mid-July in Missouri.

B. Status and distribution

Bald eagles south of the 40th parallel were listed as endangered under the Endangered Species Preservation Act of 1966 (16 U.S.C. 668aa-668cc) on March 11, 1967 (32 FR 4001). In 1978, the Service listed the species throughout the lower 48 states as endangered, except in Michigan, Minnesota, Wisconsin, and Oregon, where it was designated as threatened. (43 FR 6233, February 14, 1978). On June 12, 1995, the Service published a final rule reclassifying the status of the bald eagle from federally endangered to threatened throughout the lower 48 states (60 FR 36000). Currently, the Service is drafting a proposed rule to remove the bald eagle in the lower 48 states from the Federal list of endangered and threatened wildlife (Jody G. Millar, U.S. Fish and Wildlife Service, Rock Island, Illinois, in litt. January 29, 1999). No Critical Habitat has been designated for the species.

Five recovery regions (Pacific, Southwestern, Southeastern, Chesapeake Bay, and Northern States) have been designated for the eagle in the lower 48 states. Missouri is within the Northern States Recovery Region. The Service published the Northern States Bald Eagle Recovery Plan in 1983. Major recovery steps outlined in the plan include: (1) determine current population and habitat status; (2) determine population and habitat levels needed to achieve recovery; (3) protect, enhance, and increase bald eagle populations and habitats; and (4) establish and maintain communication to coordinate and conduct recovery efforts.

The bald eagle occurs throughout most of the United States and Canada where it nests near water. It is the only species of sea eagle native to North America. Historically, the species ranged throughout much of North America, nesting along both coasts from Florida to Baja California in the south, and from Labrador to the western Aleutian Islands, Alaska, in the north (Gerrard and Bortolotti 1988). Currently, bald eagles continue to thrive in Alaska, coastal British Columbia, and in the boreal forests and maritime provinces of Canada. In the lower 48 states, eagle populations in the northwest, Great Lakes, northeast and Florida have expanded considerably and areas that were previously void of nesting eagles are now repopulated throughout much of the eagle's historic range.

Reasons for this species previous decline have been well documented. These include: 1) environmental contamination, particularly organochlorine insecticides like DDT which caused egg-shell thinning and reproductive failure, and the illegal use of pesticides, 2) human disturbance of eagle nests and night roosts, 3) intentional killing by shooting or poisoning, and 4) the degradation and alteration of roosting and nesting habitat (U.S . Fish and Wildlife Service 1983a; Millar 1995). Illegal shooting continues to threaten the species in some parts of the country, particularly in some western states. Between 1985 and 1990 the National Wildlife Health Research Center in Madison, Wisconsin had diagnosed over 150 bald eagle deaths due to

gun shot (Millar 1995).

The ban on use of DDT and other organochlorine insecticides in the 1970's and 80's has profoundly benefited bald eagle recovery. Nonetheless, pesticide poisoning of eagles has continued. Organochlorines have been replaced by organophosphates and carbamates which are much less persistent in the environment (Stinson and Bromley 1991). However, these compounds are acetylcholinesterase inhibitors and can be extremely toxic to birds and mammals. The National Wildlife Health Research Center has diagnosed over 100 cases of contaminant poisoning over the past 15 years. Poisonings have been attributed to phorate, carbamate, fenthion, and famphur, mostly in the western states. Secondary poisonings of bald eagles have increased in the Plains and Rocky Mountain regions from pesticide-laced carcasses used to kill predators. Eagle reproduction in the Great Lakes is still impaired by persistent contaminants such as PCBs. Heavy metals such as mercury and lead have also been implicated in the poisoning deaths of bald eagles and may have severe chronic effects on reproduction. Secondary lead poisoning has been associated with eagles ingesting lead shot while feeding on crippled waterfowl. As was the case with organochlorine insecticides, this problem should be abating because of bans on lead shot for waterfowl hunting (Millar 1995).

Steps to reduce continued threats to the bald eagle have been undertaken by all levels of government and numerous private conservation groups nationwide. Increased protection of nesting habitat and winter roost sites has occurred in many areas throughout the country. Guidelines have been developed in many areas to minimize human disturbance around nesting and winter roost sites. Many harmful pesticides implicated in the death of bald eagles in the past have been banned and the levels of some persistence organochlorines or their metabolites have decreased in areas where the species is highly susceptible to contamination (Wiemeyer 1993; Millar 1995; Millar in litt. January 22, 1999). The species has also benefitted from several years of captive propagation, reintroduction, and transplanting programs as well as numerous public outreach and education efforts throughout the country.

Since the bald eagle was listed in 1978, populations have clearly increased in number and expanded in range throughout the United States and the recovery objectives outlined in several region recovery plans have been greatly exceeded. In 1963, the National Audubon Society reported that only 417 active nests occurred in the lower 48 states, with an average of 0.59 young produced per active nest. By 1994, about 4,450 occupied breeding areas were reported by the states with an estimated average young per occupied territory (n= 4,110 territories) of 1.17. Compared to 1974, the number of occupied breeding areas has increased 462 percent, and since 1990, there has been a 47% increase. As a result of the significant increase in numbers of nesting pairs, increased productivity and greatly expanded distributions, the species was reclassified in the lower 48 states from endangered to threatened where it had not already been so designated (Millar, in litt. January 22, 1999).

Recovery of the bald eagle in the lower 48 states is continuing at an impressive rate. In the past 10 years, the bald eagle's nesting population has increased at an average rate of about 9 percent

per year. The current nesting population is more than tenfold larger than the level reported by the National Audubon Society in 1963. In 1997, the Service estimated that the breeding population of the bald eagle exceeded 5,290 pairs. The species' population numbers have approximately doubled every 7-8 years for the past 30 years.

Population increases in the Northern States Recovery Region and Missouri parallel national trends. In 1994, there were 1,772 known occupied territories distributed over 21 states in the recovery region with an estimated 1.26 young per occupied territory. Since 1990, productivity has hovered around 1.00 young per territory per year. Delisting goals for this region call for 1,200 occupied territories distributed over a minimum of 16 states with an average annual productivity of at least 1.0 young per occupied nest.

Delisting goals were accomplished in 1991 with 1,349 occupied territories distributed over 20 states and an estimated average productivity exceeding 1.1 young per occupied territory. Although Missouri has not yet achieved its year 2000 recovery goal of 50 occupied breeding territories (defined as "productive territories by MDC- Wilson, in litt. September 17, 1998), it has exceeded the Region's goal of 1.0 young per occupied nest. In 1998, occupied breeding territories in the state yielded 2.0-2.2 young per occupied nest.

In Missouri, bald eagles apparently nested along several of the state's rivers and in the southeastern swamps prior to 1850. By 1900, however, the species nearly disappeared as a breeding species in the state (Robbins and Easterla 1992). In recent years, bald eagles have shown a remarkable recovery in the state and both nesting and wintering records have increased dramatically (Tables 1 and 2.). In 1984, only one bald eagle breeding territory was documented in the state and it was unproductive. In 1985, there were two productive territories and four young were fledged. The number of eagles nesting in the state increased gradually and by 1998, 36-39 productive territories produced between 65 and 70 young (Table 1).

The number of bald eagles wintering in the state has also gradually increased from 955 in 1981 to 2,621 in 1997 (Table 2). Percentages of immatures in the wintering population has ranged between 30% and 43% (Robbins and Easterla 1992; Wilson, in litt., February 8, 1995). Fewer numbers observed within the last two winters are probably attributable to the relatively mild winters of 1997-98 and this year.

Large concentrations of eagles occur at aquatic habitats scattered across the state in areas where there is either an abundance of fish (e.g., the locks and dams on the Mississippi River, Table Rock Lake, Lake Wappapello), and waterfowl concentrations (e.g., Squaw Creek NWR, Iatan Power Plant). Some concentrations, however, occur in upland areas where dead chickens or piglets associated with animal husbandry operations have been discarded. During the December 19, 1978 Squaw Creek NWR Christmas Bird Count, 417 individuals were counted (291 adults and 126 immatures). During MDC's mid-winter bald eagle survey of January 5-9, 1998, major concentrations were observed along the Missouri River in Atchinson County (180 between Highway 136 and the Iowa border), on the Osage River in Miller County (124), in western Barry

County (193) and on Table Rock Lake in Stone County (129) (Jim D. Wilson, MDC, in litt. February 23, 1998). Concentrations observed in 1999 were at the Iatan Power Plant in Platte County (127), on the Osage River in Miller County (119) and in the Washburn area of Barry County (63) (Wilson, in litt. February 18, 1999).

Table 1. Bald eagle nesting territories, productive territories, and number of young fledged in Missouri between 1984 and 1998 (Jim D. Wilson, MDC, in litt. September 17, 1998).

Year	Total Territories	Productive Territories	Number of Young Fledged
1984	1	0	0
1985	2	2	4
1986	2	2	5
1987	4	2	4
1988	6	5	7
1989	6	4	5
1990	11	4	8
1991	13	8	13
1992	11	10	21
1993	14	10	18
1994	14	13	25
1995	24	19	38
1996	27	22	37-44
1997	36	28-30	56-64
1998	45	36-39	65-70

Known night roosts are also scattered across the state with recent records from Atchinson, Barry, Cape Girardeau, Chariton, Clark, Holt, Jefferson, Lewis, Livingston, McDonald, Oregon, St. Charles, and Ste. Genevieve counties (MDC Natural Heritage Database 1997). The largest concentrations involve 104 birds on the Elk River in McDonald County, 63 birds at Roaring River State Park in Barry County, and 52 birds at a roost along the Mississippi River in Lewis County (MDC Natural Heritage Database, 1997).

As with their improved status throughout the lower 48 states, the bald eagle has recovered in Missouri. It is expected that the number of nesting and wintering individuals in the state will continue to increase.

C. Status of the species within the action area

Most of the bald eagles sighted on the Mark Twain National Forest have been wintering individuals seen singly or in small groups (Houf, pers. comm., February 28, 1998). Water bodies

on the forest which receive the most consistent use are Table Rock Lake, Lake Wappapello, and the Eleven Point and Current rivers. Other lakes and streams on the forest also support some eagles during the winter. Eagles also use private lands and other ownerships intermixed with National Forest lands, particularly near hog lots, poultry farms, fish hatcheries and other steady food sources.

Table 2. Numbers of bald eagles observed in Missouri during MDC's annual mid-winter count between 1981 and 1999 (Wilson, in litt. February 18, 1999).

Year	Number of bald eagles observed
1981	955
1982	779
1983	908
1984	975
1985	758
1986	977
1987	1,070
1988	966
1989	1,011
1990	1,654
1991	1,815
1992	1,700
1993	2,394
1994	2,054
1995	2,398
1996	2,616
1997	2,621
1998	2,009
1999	2,363

None of Missouri's seventeen overwintering night roost sites occur on Mark Twain National Forest lands (MDC, Natural Heritage Database, 1997). The nearest site is the Bailey Chapel night roost on private land in Oregon county. This site is within 1.5 miles of the Mark Twain National Forest boundary and is approximately five miles from the nearest point of the Eleven Point National Scenic River Zone. In 1994, this location was a site for a feeding aggregation and night roost of 14 eagles; 8 adults and 6 immatures (MDC, Natural Heritage Database, 1997).

The large night roost on the Elk River in McDonald County previously discussed is on private property and is over 40 miles from the Forest boundary of the Cassville District. Another roost at

Big Sugar Creek State Park in McDonald County (with 2-32 birds) (MDC Natural Heritage Database 1997) is about 30 miles from National Forest land. The large roost at Roaring River State Park is directly adjacent to the Ava District of the MTNF). The only known bald eagle roost occurring on the MTNF is a daytime roost at Loften Hole, Table Rock Lake, Stone County (Forest Service 1998).

Although there are no known bald eagle nest locations currently on the MTNG, a few are located within 1.5-6 miles of the National Forest land boundaries. One active site under private ownership is located on the Gasconade River approximately two miles from National Forest land and another inactive, privately owned site is on a tributary stream of Beaver Creek adjacent to the Hercules Glade Wilderness Area (MDC Natural Heritage Database 1997). Two active nests at Lake Wappapello and the Mingo National Wildlife Refuge are approximately 1.5 and 6.0 miles, respectively from National Forest land on the Popular Bluff District. All active nests are beyond the Primary, Secondary, and Tertiary protective zones recommended in Appendix E of the Northern States Bald Eagle Recovery Plan (U.S. Fish and Wildlife Service 1983a), and outside the 1320 feet restrictive buffer zone identified in the standards and guidelines (pg. IV-50) of the LMRP for the MTNF for Forest Service management activities during nesting season.

Small numbers of wintering bald eagles are scattered along the rivers, creeks, streams, and lakes within the MTNF (e.g., Current River, Eleven Point River, Big Piney River, Gasconade River, Black River, St. Francis River, Cedar Creek, Courtois Creek, Huzzah Creek, Table Rock Lake, Lake Wappapello). Given the continued increase in the wintering population of bald eagles in the state and the fact that the species frequents upland areas where dead chickens or piglets associated with animal husbandry operations have been discarded, it could possibly be encountered anywhere on the MTNF.

D. Effects of the action (direct and indirect effects)

Direct effects

The only potential direct effects to bald eagles on the MTNF would be: 1) the removal of unknown night roosts, 2) human disturbance, and 3) adverse impacts from smoke inhalation during prescribed fires. The Service estimates that the chances of incidental take due to the removal of known perching trees or unknown night roosts to be extremely remote for the following reasons:

- ☞ All units scheduled for harvest, thinning, or site improvement operations are visited several times by various Forest Service personnel prior to any habitat alterations being performed, and searches for eagle sign are conducted (Forest Service 1998); consequently, any unknown night roosts would likely be discovered;

- ☞ The Forest Service has indicated that "if night roosts were located during field inspections, the project would be altered to protect the roost site" according to standards and guidelines outlined in the LRMP (IV-50) (U.S. Forest Service 1998:14- bald eagle);

- ☞ Specific standards and guidelines in the LRMP for riparian corridors, floodplain forests, and specially designated or proposed specially designated areas (e.g., Eleven Point National Scenic River, Lower Current River, Cedar Creek, Big Piney River, Courtois Creek, Gasconade River, Huzzah Creek, St. Francis River) (LRMP: IV-46, 53-55, 189-190, 201-205; 221-215) provide buffer zones that restrict most types of management activities; and

- ☞ There is an abundance of suitable perching and roosting trees within all areas of the MTNF where eagles have been observed.

Removal of trees used for perching or roosting could occur during timber management activities (i.e. harvesting, thinning, salvage operations), road construction and maintenance, exploratory drilling, range improvement, recreation site maintenance, and special use administration (e.g., firewood removal, utility corridor maintenance, etc.). Because no known night roosts have been discovered to date on upland areas of the MTNF and Forest Service personnel search areas scheduled for management prior to operations, it is highly unlikely that eagle perch or roost trees would be removed. The greatest potential would be when these activities are undertaken in riparian corridors or along lake shores. Although there are several standards and guidelines in the LRMP for the MTNF that provide protection for riparian corridors (see above), a minute amount of riparian/bottomland hardwoods have been harvested in the last 10 years (i.e., 442 acres or an average of ca. 44.2 acres per year- U.S. Forest Service 1998). No standards and guidelines have been specifically written for lake shores (U.S. Forest Service 1986).

The greatest potential of incidental take would be those activities on Forest Service land at Table Rock Lake and Lake Wappapello where the largest numbers of eagles have been observed on the MTNF. However, even here it is highly unlikely that eagle perch or roost trees would be removed because the majority of land on the MTNF encompassing Table Rock Lake and Lake Wappapello frontage is managed as recreational areas (pers. commun., Houf, February 26, 1999).

Human disturbance associated with forest management activities and other operations on the MTNF, or recreational users on the Forest could cause bald eagles to flush from a specific perch but it is doubtful that such activities would be at a magnitude to constitute take. Additionally, eagles have become acclimated to small levels of human activity (U.S. Forest Service 1998).

Prescribed fires conducted on the MTNF, especially those conducted near Table Rock Lake, Lake Wappapello, and the rivers, creeks, and streams where eagles forage may directly impact perching or foraging eagles due to smoke inhalation if prevailing winds drift smoke into occupied areas. Such potential impacts would probably be minimal, however, for the following reasons: 1) prescribed fires are not conducted in riparian corridors (U.S. Forest Service 1998), the majority of land on the MTNF encompassing Table Rock Lake and Lake Wappapello frontage is managed as recreational areas where the use of this management tool is not anticipated (pers. commun., Houf, February 26, 1999). Nonetheless, smoke from prescribed fires conducted on areas adjacent to

these water bodies could drift to locations occupied by eagles.

Indirect effects

Indirect effects are defined as those that are caused by the proposed actions and are later in time, but still are reasonably certain to occur (50 CFR 402.02). The main potential indirect effects to the bald eagle on the MTNF would be: 1) the loss of the species' prey base due to the degradation of water quality of streams, rivers, and lakes that might negatively impact the fish populations that provide a forage base for eagles, and 2) loss of future roosting habitat due to the alteration of riparian corridors and lake shore habitat. It is believed, however, that, adverse impacts to the species due to indirect effects is expected to be remote for the following reasons.

The U.S. Geological Survey conducted an extensive water quality study of the Ozark Plateaus in Arkansas, Kansas, Missouri (including basins that cover National Forest land in most districts of the MTNF), and Oklahoma between 1992 and 1995, and concluded that the water quality was well within acceptable levels for several parameters established by EPA (Petersen *et al.* 1998). Sedimentation, however, was not included in their analysis, and it is likely that it would be the main contributing factor to water degradation on the MTNF. Contrary to conclusions stated by the Forest Service in their 1998 Biological Assessment, the Service believes that sedimentation from activities on the MTNF could potentially adversely impact streams, rivers, and lakes on the MTNF where the species forages, even if the standards and guidelines outlined in the LRMP for the National Forest are followed. Ground-disturbing forest management activities, such as some timber harvesting, road construction and maintenance, prescribed fires, overgrazing, ATV and motor bike use, and trampling from livestock have the potential for soil to move off site. The Service would predict, however, that potential adverse impacts from siltation is likely to be minimal because: 1) very little management is undertaken within riparian corridors and along the lake shore of Table Rock Lake and Lake Wappapello because these areas are managed primarily as recreational areas (Houf, in litt. March 1, 1999), and 2) standards and guidelines outlined in the LRMP for the MTNF provide recommendations that minimize soil erosion and maintain good water quality. Nonetheless, sediment transport into aquatic systems from activities upslope of riparian corridors is possible.

E. Cumulative effects

Cumulative effects include the combined effects of any future State, local, or private actions that are reasonably certain to occur within the action area covered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA. Additionally, any future Federal, State, local, or private actions that are reasonably certain to occur in the action area, and which are considered in this biological opinion, will either be carried out by, or will require a permit from, the Forest Service; they will, therefore, require compliance with Section 7 of the ESA. Because the Service is not aware of any future State, local, or private actions that are reasonably certain to occur within the action area and which would not be subject to Forest Service Section 7 review, cumulative effects, as defined by the ESA, will not occur and will not be addressed further in this opinion.

F. Conclusion

After reviewing the current status of bald eagle; the environmental baseline for the action area; the effects of forest management and other activities on the MTNF (both direct and indirect); additional measures identified in the Forest Service's BA to assist in the protection, management, and recovery of the species; and any potential cumulative effects, it is the Service's biological opinion that forest management and other activities authorized, funded, or carried out by the MTNF, are not likely to jeopardize the continued existence of the bald eagle. Because critical habitat has not been designated for this species, none will be adversely affected by the continued implementation of the LRMP.

G. Incidental take statement

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act, prohibit the take of endangered and threatened species, respectively, without special exemption. Take is definded as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns, including breeding, feeding, or sheltering. Harass is defined the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of Section 7(b)(4) and Section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are **non-discretionary**, and must be undertaken by the Forest Service (MTNF) so that they become binding conditions of any grant or permit issue to an applicant, as appropriate, for the exemption of Section 7(o)(2) to apply. The Forest Service (MTNF) has a continuing duty to regulate the activity covered by this incidental take statement. If the Forest Service (MTNF) (1) fails to assume and implement the terms and conditions, or (2) fails to require an applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of Section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Forest Service must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement [50 CFR § 402.14(i)(3)].

H. Amount or extent of incidental take anticipated

The Service anticipates that incidental take of bald eagles as a result of forest management activities or other actions implemented from the LRMP on the MTNF (including timber management operations, human disturbance, prescribed fires, and indirect effects) will be difficult to quantify and detect for the following reasons: 1) there is an abundance of roost trees available to eagles throughout the forest; it would therefore, be difficult to document that the harm or harass

provisions of take resulted from the loss of a particular tree when numerous, alternative roosts are available for roosting, 2) eagles have become acclimated to some level of human activity on the Forest (U.S. Forest Service 1998), 3) the Service is unaware of any study that has accurately identified the degree of impact to bald eagles from drifting smoke that originated from prescribed fires adjacent to occupied areas, and 4) it is unlikely that activities that could adversely impact the water quality of rivers, lakes, creeks, and streams where the species forages would be of such magnitude to appreciably decrease this species forage base.

I. Effect of the take

The Service has determined that the level of unquantifiable, anticipated take of bald eagles is not likely to result in jeopardy to the species.

J. Reasonable and prudent measures

Although the Service has determined that the level of incidental take for this species is unquantifiable, the following reasonable and prudent measures are necessary and appropriate to minimize any adverse impacts to bald eagles on the MTNF:

- ☞ Reduce the potential of removing unknown communal night roosts.

- ☞ Discourage continuous and/or repeated human disturbance where wintering eagles (November 15 and March 15) are known to have communal night roosts or form daily congregations [as defined in the Northern States Bald Eagle Recovery Plan (U.S. Fish and Wildlife Service1983a)] on all lands or waters managed by the MTNF.

- ☞ Use appropriate smoke management techniques to minimize potential impacts of smoke inversion to occupied communal night roosts, daytime concentrations, or occupied breeding territories.

- ☞ In association with the predicted removal of this species from the list of endangered and threatened wildlife, assist the Service and MDC in monitoring the status of the species on the MTNF up through the five years following delisting according to requirements outlined in the ESA.

The Service believes that the reasonable and prudent measures outlined above will significantly reduce the impacts of incidental take of bald eagles on the MTNF and that these measures are reasonable and fall within the Forest Service's responsibilities to conserve federally listed species as outlined in Sections 2(c)(1) and 7(a)(1) of the Act.

K. Terms and conditions

In order to be exempt from the prohibitions of section 9 of the Act, the Forest Service (MTNF) must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline the required reporting/monitoring requirements. These terms and conditions are non-discretionary.

In order to decrease the potential of removing of unknown communal night roosts, the following is necessary:

- ☞ Conduct a minimum of 3, annual winter (early, middle, and late) searches (aerial and/or ground) to locate any previously unknown communal night roosts or eagle concentrations following criteria outlined in the Northern States Bald Eagle Recovery Plan (U.S. Fish and Wildlife Service1983a). Searches will focus on areas eagles are known to frequent, where congregations of eagles have been previously documented, or where there are concentrated food sources (such as poultry farms, hog lots, aquaculture facilities, etc.) near lands or waters managed by the MTNF.

- ☞ Any bald eagle communal night roosts and concentrations discovered during winter surveys or during any additional field surveys of proposed project areas shall be protected following guidelines outlined in the Northern States Bald Eagle Recovery Plan (U.S. Fish and Wildlife Service1983a).

- ☞ Provide an annual report, by June 1 of each year, to the Service's Columbia, Missouri Ecological Services Field Office, and MDC, that will include the following information: 1) results of any winter searches for communal night roosts and concentrations, including mid-winter surveys conducted in cooperation with the Service/MDC, and 2) discovery of any nesting territories on lands managed by the MTNF.

In order to decrease human disturbance, the following is necessary:

- ☞ Designate, on National Forest System Lands, a 1/4 mile wide old growth corridor along the waters edge of traditional bald eagle wintering areas such as Table Rock Lake and Lake Wappapello..

- ☞ Provide an annual report, by June 1 of each year, to the Service's Columbia, Missouri Ecological Services Field Office, and MDC, any documented case of incidental take of bald eagles on lands and waters managed by the MTNF.

- ☞ Protect super-canopy (Tyrell, et al. 1998) or other identified congregation roost trees along major river corridors, lakes, and lands managed by the MTNF, in addition to adhering to standards and guidelines outlined in the LRMP for riparian corridors and specially designated rivers such as the Eleven Point and Lower Current rivers.

In order to minimize potential impacts of smoke inversion to occupied communal night roosts, daytime concentration sites, or occupied breeding territories, it is necessary to:

- ☞ Consider all occupied eagle communal night roosts, daytime concentration sites, or breeding sites (if and when discovered on the MTNF) as smoke sensitive areas. Conduct any planned prescribed fire in the vicinity of occupied bald eagle site only when the

following have been considered: wind direction, speed, mixing height and transport winds needed in burn planning and implementation to minimize smoke from drifting toward an occupied roost site. Prevent smoke inversion from occurring at roost sites.

- ☞ Provide an annual report, by June 1 of each year, to the Service's Columbia, Missouri Ecological Services Field Office, and MDC, any documented case of a prescribed fire that behaved contrary to predicted movement patterns and which resulted in a confirmed adverse impact to bald eagles.

- ☞ Prior to the employment of any prescribed fire, provide the Service's Columbia, Missouri Ecological Services Field Office with the opportunity to review burn plans that could potentially impact bald eagles.

In order to assist the Service and MDC in monitoring the status of the species on the MTNF up through the five years following delisting according to requirements outlined in the ESA, it is necessary to:

- ☞ Continue cooperation with the Service and MDC on mid-winter eagle surveys to monitor eagle numbers and identify communal night roosts on all lands and waters managed by the MTNF.

L. Conservation recommendations

Sections 2(c)(1) and 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purpose of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

The Service recommends that the MTNF implement the following conservation measures for the benefit of the bald eagle:

- ☞ In cooperation with the Service, the Army Corps of Engineers (COE), MDC, and the Missouri Department of Natural Resources (MDNR), explore the possibility of the development of a study to determine the impact of recreational activities on Table Rock Lake and Lake Wappapello to the large concentration of eagles wintering there; provide the results of such a study to the Service's Columbia, Missouri Ecological Services Field Office and to MDC by June 1 of the year following the completion of the analysis.

- ☞ Continue to monitor and document any significant soil movement as a result of various

management activities undertaken by the Forest Service. Cooperate with other agencies and/or universities in ongoing or new studies which would help determine if activities on the MTNF contribute to sediment deposition into streams, rivers, and lakes. Cooperate in any studies regarding potential effects of excess sedimentation on forage fish on which the bald eagle feeds. Provide monitoring results to the Service's Columbia, Missouri Ecological Services Field Office and to MDC no later than December 31 of each year. This study should be done in conjunction with the conservation recommendation outlined above for the gray bat.

- In consultation with the Service and MDC, develop and provide an educational brochure to recreational users of all rivers, streams, creeks, and lakes where the bald eagle occurs that outlines steps to minimize potential impacts to the species.

- In consultation with the Service and MDC, develop an educational slide program on the status of the bald eagle in the lower 48 states, Missouri, and on the MTNF; reasons it was listed; and reasons for its recovery and eventual delisting. This program should be made available to all districts of the MTNF, but especially to the Ava and Poplar Bluff districts due to the high relatively concentration of eagles at Table Rock Lake and Lake Wappapello and the large number of visitors to the two areas. Such a program should be developed in cooperation and coordination with personnel of the Army Corps of Engineers, and Missouri Department of Natural Resources at Table Rock Lake and Lake Wappapello State parks.

- Provide field training for new Forest Service employees so they will be able to recognize bald eagle sign at night roosts, even when eagles are absent.

- Continue cooperation with MDC to provide good fish habitat on streams, rivers, and lakes of the MTNF.

Note: the Service will not refer the incidental take of any bald eagle for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. §§ 703-712), or the Bald and Golden Eagle Protection Act of 1940, as amended (16 U.S.C. §§ 668-668d), if such take is in compliance with the terms and conditions specified in this opinion.

Indiana bat

A. Species/habitat description/life history

The Indiana bat is a medium-sized, monotypic species of the genus *Myotis*. Its forearm length is $1^3/_8$ - $1^5/_8$ inches [in] (35 to 41 millimeters [mm]). The head and body length ranges from $1^5/_8$ - $1^7/_8$ in (41 to 49 mm). This species closely resembles the little brown bat (*M. lucifugus*) and the northern long-eared bat (*M. septentrionalis*). The Indiana bat usually has a distinctly keeled calcar. The hind feet tend to be small and delicate with fewer, shorter hairs (do not extend beyond the toenails) than its congeners. The fur lacks luster (Hall, 1981; Barbour and Davis, 1969). The

ears and wing membranes have a dull appearance and flat coloration that do not contrast with the fur. The fur of the chest and belly is lighter than the flat (not glossy), pinkish-brown fur on the back, but does not contrast as strongly as does that of the little brown bat or northern long-eared bat, for example (U.S. Fish and Wildlife Service 1999). The skull has a small sagittal crest, and the braincase tends to be smaller, lower, and narrower than that of the little brown bat (Hall, 1981; Barbour and Davis, 1969).

Habitat requirements

1. Winter habitat. Indiana bats require specific roost sites in caves or mines (Tuttle and Taylor 1994) that attain appropriate temperatures to hibernate. In southern parts of the bat's range, hibernacula trap large volumes of cold air and the bats hibernate where resulting rock temperatures drop; in northern parts of the range, however, the bats avoid the coldest sites. In both cases, the bats choose roosts with a low risk of freezing. Ideal sites are 50°F (10°C) or below when the bats arrive in October and November. Early studies identified a preferred mid-winter temperature range of 39-46°F (4-8°C), but a recent examination of long-term data suggests that a slightly lower and narrower range of 37-43°F (3-6°C) may be ideal for the species (U.S. Fish and Wildlife Service 1999). Only a small percentage of available caves provide for this specialized requirement. Stable low temperatures allow the bats to maintain a low rate of metabolism and conserve fat reserves through the winter, until spring (Humphrey, 1978; Richter *et al.*, 1993). Indiana bats will occasionally use sites other than caves or mines if microclimate conditions are favorable. Kurta and Termanio (1994) found a single Indiana bat roosting with a large colony of 15,000 bats (mostly little brown and northern long-eared bats) at a hydroelectric dam in Manistee County, Michigan and noted that the temperature was about 4.7 ° C.

Relative humidity at roost sites during hibernation usually is above 74% but below saturation (Hall, 1962; Humphrey, 1978; LaVal *et al.*, 1976; Kurta and Teramino 1994), although relative humidity as low as 54% has been observed (Myers, 1964). Humidity may be an important factor in successful hibernation (Thomas and Cloutier, 1992).

Specific cave configurations determine temperature and humidity microclimates, and thus suitability for Indiana bats (Tuttle and Stevenson, 1978; LaVal and LaVal, 1980). Indiana bats select roosts within hibernacula that best meet their needs for cool temperatures; in many hibernacula, these roosting sites are near an entrance, but may be deeper in the cave or mine if that is where cold air flows and is trapped (Tuttle and Stevenson, 1978; U.S. Fish and Wildlife Service 1999).

Indiana bats often hibernate in the same hibernacula with other species of bats, and are occasionally observed clustered with or adjacent to other species including gray bats (*Myotis grisescens*), Virginia big-eared bats (*Plecotus townsendii virginianus*), little brown bats, and northern long-eared bats (Myers 1964; LaVal and LaVal 1980; Kurta and Teramino 1994).

2. Summer habitat. A full, well-integrated understanding of the summer needs of this endangered species is yet to be attained. Early researchers considered flood plain and riparian forest to be the

primary roosting and foraging habitats used in the summer by the Indiana bat (Humphrey *et al.*, 1977), and these forest types unquestionably are important. More recently, upland forest has been shown to be used by Indiana bats for roosting (Clark *et al.*, 1987; Gardner *et al.*, 1991*b*; Callahan *et al.*, 1997; John MacGregor, Daniel Boone National Forest, Kentucky, in litt. April 14, 1997); and upland forest, old fields, and pastures with scattered trees have been shown to provide foraging habitat (Gardner *et al.*, 1991*b*; MacGregor, in litt. April 14, 1997).

Indiana bats occupy highly altered landscapes in many areas in the eastern United States and use ephemeral, mostly dead and dying trees for roosting. Anecdotal evidence suggests that the Indiana bat may, in fact, respond positively to some degree of habitat disturbance. In northern Missouri, maternity roosts were found in areas that were heavily disturbed (Callahan 1993; Miller 1996). Timber harvest activities neither directly damaged known roosts nor discouraged bats from continuing to forage in an area that had been harvested in Illinois(Gardner *et al.*, 1991*a*), and the species has been found roosting in shelterwood cuts in Kentucky (U.S. Fish and Wildlife Service 1999).

Analysis of landscape changes in Missouri, especially in the Ozarks provides strong, convincing evidence that Indiana bats evolved in an open to semi-open savanna-like environment, at least in the western part of the species' range (Marbut 1914; Sauer 1920; Schroeder 1981; Giessman *et al.* 1986; Ladd 1991; Nigh *et al.* 1992; Jacobson and Primm 1997). This is supported by the analysis conducted of several maternity sites by Romme *et al.* (1995) who found that most roosts were located in areas that had a canopy closure of 60 to 80%. Humphrey *et al.* (1977) hypothesized that roost trees were usually located in openings within the forest because they provided the necessary thermoregulatory characteristics.

Within the range of the species, the existence of Indiana bats in a particular area may be governed by the availability of natural roost structures, primarily standing dead trees with loose bark. The suitability of any tree as a roost site is determined by (1) its condition (dead or alive), (2) the quantity of loose bark, (3) the tree's solar exposure and location in relation to other trees, and (4) the tree's spatial relationship to water sources and foraging areas.

A number of tree species have been reported to be used as roosts by Indiana bats. These include: American beech (*Fagus grandifolia*), ashes (*Fraxinus* spp.), black gum (*Nyssa sylvatica*), black locust (*Robinia pseudo-acacia*), cottonwood, elms (*Ulmus* spp.), hickories (*Carya* spp.), maples (*Acer* spp.), oaks (*Quercus* spp.), pines (*Pinus* spp.), sassafras (*Sassafras albidum*), sourwood (*Oxydendrum arboreum*), sweet birch (*Betula lenta*), and yellow buckeye (*Aesculus octandra*) (Cope *et al.*, 1974; Humphrey *et al.*, 1977; Gardner *et al.*, 1991*a, b;* Garner and Gardner 1992; Kurta *et al.*, 1993*a*; Romme *et al.* 1995; Kiser and Elliott, 1996; Kiser *et al.*, 1996; Kurta *et al.*, 1996; MacGregor, in litt., September 3, 1996; Callahan *et al.*, 1997; MacGregor in litt. April 14, 1997). Morphological characteristics of the bark of a number of trees make them suitable as roosts for Indiana bats; that is, when dead, senescent, or severely injured (e.g., lightning-struck) trees possess bark that springs away from the trunk upon drying. Additionally, the shaggy bark of some living hickories (*Carya* spp.) and large white oaks (*Quercus alba*) also provide roost sites.

The most important characteristics of trees that provide roosts are not species but structure: exfoliating bark with space for bats to roost between the bark and the bole of the tree. The length of persistence of peeling bark varies with the species of tree and the severity of environmental factors to which it is subjected.

Occasionally, tree cavities or hollow portions of tree boles and limbs provide roost sites for Indiana bats (Gardner *et al.*, 1991*a*; Kurta *et al.*, 1993*b*). A crevice in the top of a lightning-struck tree (Gardner *et al.*, 1991*a*), and splits below splintered, broken tree tops have also been used as roosts (U.S. Fish and Wildlife Service 1999).

Indiana bat maternity colonies use multiple roosts, in both dead and living trees. Exposure of roost trees to sunlight and location relative to other trees are important factors in suitability and use. Because cool temperatures can delay the development of fetal and juvenile young (Racey, 1982), selection of maternity roost sites may be critical to reproductive success. Dead trees with east-southeast and south-southwest exposures may allow solar radiation to effectively warm nursery roosts. Roosts in some species of living trees (e.g., shagbark hickory [*Carya ovata*]), on the other hand, may provide better protection from rain water and other unfavorable environmental conditions. Their greater thermal mass holds more favorable temperatures for roosting bats during cool periods (Humphrey *et al.*, 1977).

Most roost trees used by a maternity colony are close together. The spatial extent and configuration of a colony's regular use area is probably determined by the availability of suitable roosts. The distances between roosts occupied by bats within a single maternity colony have ranged from just a few meters for nearest distance to another roost to several kilometers (km) and, in one case, five km for furthest distance between roosts (Callahan *et al.*, 1997; U.S. Fish and Wildlife Service 1999). Miller (1996) compared habitat variables for sites in northern Missouri where surveys for Indiana bats had been conducted and noted that significantly larger trees [> 30 centimeters (cm) (12 in) diameter breast height (dbh)] were found where reproductively active Indiana bats had been netted, than at sites at where bats had not been captured.

Indiana bat maternity roosts can be described as "primary" or "alternate" based upon the proportion of bats in a colony occupying the roost site, and location in relation to forest canopy cover (Callahan *et al.*, 1997; Kurta *et al.*, 1996). Maternity colonies have at least one primary roost (up to three have been identified for a single colony) that is used by the majority of the bats throughout the summer. Colonies also use multiple alternate roosts that are used by small numbers of bats intermittently throughout the summer (U.S. Fish and Wildlife Service 1999). Kurta *et al.* (1996) studied a maternity colony in northern Michigan over a three-year period and noted that roosting bats changed roost trees every 2.9 days and that the number of roosts used by the colony ranged from five to 18.

Primary roosts are located in openings or at the edge of forest stands, while alternate roosts can be in either the open or the interior of forest stands. Thermoregulatory needs may be a factor in roost site selection. Primary roosts are not surrounded by closed canopy and can be warmed by solar

radiation, thus providing a favorable microclimate for growth and development of young during normal weather. Alternate roosts tend to be more shaded, frequently are within forest stands, and are selected when temperatures are above normal or during periods of precipitation. Shagbark hickories seem to be particularly good alternate roosts because they provide cooler roost conditions during periods of high heat and their tight bark shields bats from the encroachment of water into the roost during rain events (Callahan *et al.*, 1997). Roost site selection and use may differ between northern and southern parts of the species' range, but to date, such analyses have not been undertaken.

Because roost trees used by Indiana bat roosts are ephemeral, it is not possible to generalize or estimate roost longevity due to the many factors that influence it. Bark may slough off completely or the tree may fall over. Although roosts may only be habitable for one to two years under "natural conditions" for some tree species (Humphrey *et al.* 1977), others with good bark retention such as slippery elm, cottonwood, green ash (*Fraxinus pennsylvanica*), and oaks, may provide roosting habitat four to eight years (Gardner *et al.*, 1991*a*; Callahan *et al.*, 1997; U.S. Fish and Wildlife Service 1999). Hickories also retain bark well.

Indiana bats exhibit varying degrees of site fidelity to summer colony areas, roosts, and foraging habitat. Females have been documented returning to the same roosts from one year to the next (Humphrey *et al.*, 1977; Gardner *et al.*, 1991*a,b*; Callahan *et al.*, 1997). Kurta *et al.* (1996), however, noted that individuals in a maternity colony in northern Michigan "were not highly faithful to a particular tree." In Illinois, male Indiana bats exhibited some site fidelity to summering areas that they had occupied during previous years (Gardner *et al.*, 1991*b*).

The Indiana bat may be more adaptable with regard to roosts than previously believed. Humphrey *et al.* (1977) suggested that previously used summer roosts may be important to the reproductive success of local Indiana bat populations; that if these roosts are lost or unavailable, adult females may be faced with finding suitable maternity sites at a time when they are already stressed from post-hibernation migration and the increased metabolic energy costs of pregnancy. Others, (e.g., Kurta *et al.* 1996) however, have more recently noted that Indiana bats will use multiple roost sites within a maternity colony area. Bats move from one roost to another within a season, in addition to responding to changes in environmental conditions (temperature and precipitation), and when a particular roost becomes unavailable (Gardner *et al.*, 1991*a*; Callahan *et al.*, 1997). Thus, the species appears to be an adaptable animal that takes advantage of the ephemeral habitat available to it. Nonetheless, it is apparent that a variety of suitable roosts within a colony's occupied summer range should be available to assure the continuance of the colony in that area (Kurta *et al.*, 1993*a*; Callahan *et al.*, 1997).

3. Fall and spring roosts. Indiana bats use roosts in the spring and fall similar to those selected during the summer. During the fall, when Indiana bats swarm and mate at their hibernacula, male bats roost in trees nearby during the day and fly to the cave during the night. In Kentucky, Kiser and Elliott (1996) found male Indiana bats roosting primarily in dead trees on upper slopes and ridgetops within 1.5 mi (2.4 km) of their hibernaculum. During September in West Virginia,

male Indiana bats roosted within 3.5 miles (mi) (5.6 km) in trees near ridgetops, and often switched roost trees from day to day (U.S. Fish and Wildlife Service 1999). Fall roost trees more often tend to be exposed to sunshine rather than being shaded (U.S. Fish and Wildlife Service 1999).

Upon emergence from hibernation in the spring, some males remain within the vicinity of their hibernacula, where they roost and forage in mature forest; movements of 2.5 - 10 mi (4 - 16 km) have been reported in Kentucky, Missouri, and Virginia respectively (MacGregor, pers. commun., December 1998; Hobson and Holland, 1995; 3D/International, 1996). However, other males leave the area entirely upon emergence in the spring. Females dispersing from a Kentucky hibernaculum in the spring moved 4- 10 mi (6.4- 16 km) within 10 days of emergence (MacGregor, pers. commun., December 1998).

4. Foraging habitat and behavior. Indiana bats forage in and around tree canopy of flood plain, riparian, and upland forest. In riparian areas, Indiana bats primarily forage around and near riparian and flood plain trees (e.g., sycamore [*Platanus occidentalis*], cottonwood, black walnut [*Juglans nigra*], black willow [*Salix nigra*], and oaks), and solitary trees and forest edge on the flood plain (Belwood, 1979; Cope *et al.*, 1974; Humphrey *et al.*, 1977; Clark *et al.*, 1987; Gardner *et al.*, 1991*b*). Within flood plain forests where Indiana bats forage, canopy closures range from 30 to 100% (Gardner *et al.*, 1991*b*). Cope *et al.* (1978) characterized woody vegetation with a width of at least 30 yards (~ 30 m) on both sides of a stream as excellent foraging habitat. Streams, associated flood plain forests, and impounded bodies of water (e.g., ponds, wetlands, reservoirs) are preferred foraging habitats for pregnant and lactating Indiana bats, some of which may fly up to 1½ mi (2.5 km) from upland roosts (Gardner *et al.*, 1991*b*). Indiana bats also forage within the canopy of upland forests, over clearings with early successional vegetation (e.g., old fields), along the borders of croplands, along wooded fencerows, and over farm ponds in pastures (Clark *et al.*, 1987; Gardner *et al.*, 1991*b*).

The extent of foraging area used by an Indiana bat maternity colony has been reported to range from a linear strip of creek vegetation 0.5 mi (0.8 km) in length (Belwood, 1979; Cope *et al.*, 1974; Humphrey *et al.*, 1977), to a foraging area 0.75 mi (1.2 km) in length, within which bats flew over the wooded river or around the riverside trees (Cope *et al.*, 1978). Indiana bats return nightly to their foraging areas (Gardner *et al.*, 1991*b*).

Indiana bats usually forage and fly within an air space from 6 - 100 ft (2 - 30 m) above ground level (Humphrey *et al.*, 1977). Most Indiana bats caught in mist nets are captured over streams and other flyways at heights greater than 6 ft (2 m) (Gardner *et al.*, 1989).

During summer, male Indiana bats that remained near their Missouri hibernacula flew cross-country or upstream toward narrower, more densely wooded riparian areas during nightly foraging bouts, perhaps due to interspecific competition with gray bats (*M. grisescens*). Some male bats also foraged at the edges of small flood plain pastures, within dense forest, and on hillsides and ridgetops; maximum reported distance was 1.2 mi (2 km) (LaVal *et al.*, 1976; LaVal

et al. 1977; LaVal and LaVal, 1980; MacGregor,). In Kentucky, MacGregor (pers. commun., December 1998) reported that the maximum distance males moved from their hibernaculum in the summer was about 2.6 mi (4.2 km). In the fall, male Indiana bats tend to roost and forage in upland and ridgetop forests, but also may forage in valley and riparian forest; movements of 1.8 - 4.2 mi (2.5 - 6.8 km) have been reported in Kentucky and Missouri (Kiser and Elliott, 1996; 3D/International, 1996; MacGregor, in litt. June 1997).

Life history

1. Behavior. Generally, Indiana bats hibernate from October through April (Hall, 1962; LaVal and LaVal, 1980) (September - May in northern areas [U.S. Fish and Wildlife Service 1999]), depending upon local weather conditions (Figure 1) for a depiction of the annual cycle). They hibernate in large, dense clusters, ranging from 300 bats per square foot (3,230 bats/m^2) (Clawson *et al.*, 1980) to 484 bats per square foot (5,215 bats/m^2) (Clawson, pers. observ., October 1996). Indiana bats are very loyal to their hibernacula (LaVal and LaVal, 1980).

Upon arrival at hibernating caves in August-September, Indiana bats "swarm," a behavior in which "large numbers of bats fly in and out of cave entrances from dusk to dawn, while relatively few roost in the caves during the day" (Cope and Humphrey, 1977). Swarming continues for several weeks and mating occurs during the latter part of the period. Fat supplies are replenished as the bats forage prior to hibernation. Indiana bats tend to hibernate in the same cave in which they swarm (LaVal *et al.*, 1976; Stihler, pers. observ., October 1996), although swarming has occurred in caves other than those in which the bats hibernated (Cope and Humphrey, 1977; MacGregor, pers. observ., October 1996).

During swarming, males remain active over a longer period of time at cave entrances than do females (LaVal and LaVal, 1980), probably to mate with the females as they arrive. After mating, females enter directly into hibernation. A majority of bats of both sexes hibernate by the end of November (by mid-October in northern areas [Kurta, pers. observ., June 1997]), but hibernacula populations may increase throughout the fall and even into early January (Clawson *et al.*, 1980).

Figure 1. Indiana bat annual chronology (from U.S. Fish and Wildlife Service 1999).

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Both sexes:											
Hibernation									Hibernation		
Females:			Emerge	Pregnant			Swarming				
"					Lactating						
Young:					Born	Flying					
Males:			Emerge				Swarming				
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

Adult females store sperm through the winter and become pregnant via delayed fertilization soon after emergence from hibernation. Young bats can mate in their first autumn and have offspring the following year, whereas males may not mature until the second year. Limited mating activity occurs throughout the winter and in late April as the bats leave hibernation (Hall, 1962). Females emerge from hibernation ahead of males; most winter populations leave by early May. Some males spend the summer near hibernacula in Missouri (LaVal and LaVal, 1980) and West Virginia (U.S. Fish and Wildlife Service 1999). In spring when fat reserves and food supplies are low, migration is probably hazardous (Tuttle and Stevenson, 1977). Consequently, mortality may be higher in the early spring, immediately following emergence.

Females may arrive in their summer habitats as early as April 15 in Illinois (Gardner *et al.*, 1991*a*; Brack, 1979). During this early spring period, a number of roosts (e.g., small cavities) may be used temporarily, until a roost with larger numbers of bats is established. Humphrey *et al.* (1977) determined that Indiana bats first arrived at their maternity roost in early May in Indiana, with substantial numbers arriving in mid-May. Parturition occurs in late June and early July (Easterla and Watkins, 1969; Humphrey *et al.*, 1977) and the young are able to fly between mid-July or early August (Mumford and Cope, 1958; Cope *et al.*, 1974; Humphrey *et al.*, 1977; Clark *et al.*, 1987; Gardner *et al.*, 1991*a;* Kurta *et al.*, 1996).

Most of the documented maternity colonies contained 100 or fewer adult bats. After grouping into nursery colonies, females give birth to a single young in late June or early July. Some males disperse throughout the range and roost individually or in small numbers in the same types of trees and in the same areas as females, while other males remain near their hibernacula. Maternity colonies occupy roost sites in forested riparian, flood plain, or upland habitats, and exhibit strong roost site fidelity (Cope *et al.*, 1978; Clark *et al*, 1987; Gardner *et al.* 1991*a*, *b*; Brack, 1983; Callahan *et al*, 1977; U.S. Fish and Wildlife Service 1999).

Young Indiana bats are capable of flight within a month of birth. Young born in late June may be flying as early as the first week of July (Clark *et al.*, 1987), others from mid- to late July. Indiana bats spend the latter part of the summer accumulating fat reserves for fall migration and hibernation.

Humphrey and Cope (1977) determined that female survivorship in an Indiana population of Indiana bats was 76% for ages one to six years, and 66% for ages six to 10 years; for males, survivorship was 70% for ages one to six years, and 36% for ages six to 10 years. The maximum ages for banded individuals were 15 years for females and 14 years for males. Mortality between birth and weaning has been estimated at 8% (Humphrey *et al.* 1977).

2. Food habits. Indiana bats feed solely on aquatic and terrestrial, flying insects. They are habitat generalists and their selection of prey items reflects the environment in which they forage (LaVal and LaVal 1980). Diet varies seasonally and variation is observed among different ages, sexes, and reproductive-status groups (Belwood, 1979; Lee, 1993). Reproductively active females and juveniles exhibit greater dietary diversity than males and non-reproductively active adult females,

perhaps due to higher energy demands. Reproductively active females eat more aquatic insects than do adult males or juveniles (Lee, 1993).

Moths (Lepidoptera) are major prey items identified in several studies (Belwood, 1979; LaVal and LaVal 1980; Brack and LaVal, 1985; Lee, 1993; Gardner and Virgil Brack (BHE Environmental, Inc., Cincinnati, Ohio) (unpubl. data), but caddisflies (Trichoptera) and flies (Diptera) are major prey items documented in another (Kurta and Whitaker, 1998). Another major prey group includes mosquitoes and midges (Belwood, 1979; Gardner and Brack, unpubl. data), especially species that form large mating aggregations above or near water (Belwood, 1979). Other prey include bees, wasps, and flying ants (Hymenoptera), beetles (Coleoptera), leafhoppers (Homoptera), treehoppers (Homoptera), stoneflies (Plecoptera), and lacewings (Neuroptera) (Whitaker, 1972; Belwood, 1979; Gardner and Brack, unpubl. data).
Male Indiana bats summering in or near a hibernation cave feed preferentially on moths and beetles. Additionally, caddisflies, flies, mosquitoes, midges, stone flies, leafhoppers, treehoppers, and true bugs are consumed, but in low percentages (U.S. Fish and Wildlife Service 1999). LaVal and Brack (1985) examined fecal pellets of 140 male Indiana bats and identified 83% of the prey items as Lepidoptera and 7% as Coleoptera.

B. Status and distribution

The Indiana bat (*Myotis sodalis*) was officially listed as an endangered species on March 11, 1967 (*Federal Register* 32[48]:4001) under the Endangered Species Preservation Act of October 15, 1966 (80 Stat. 926; 16 U. S. C. 668aa[c]). Critical Habitat was designated for the Indiana bat on September 24, 1976 (41 FR 41914); 11 caves and two mines in six states were listed as critical habitat: Illinois - Blackball Mine (LaSalle Co.); Indiana - Big Wyandotte Cave (Crawford Co.), Ray's Cave (Greene Co.); Kentucky - Bat Cave (Carter Co.), Coach Cave (Edmonson Co.); Missouri - Cave 021 (Crawford Co.), Caves 009 and 017 (Franklin Co.), Pilot Knob Mine (Iron Co.), Bat Cave (Shannon Co.), Cave 029 (Washington Co.); Tennessee - White Oak Blowhole Cave (Blount Co.); and West Virginia - Hellhole Cave (Pendleton Co.).

The Fish and Wildlife Service (1999) is nearing completion of an agency draft of a revised recovery plan for the Indiana bat. Reasons for updating the plan are: 1) to update the recovery plan with information on the life history and ecology of the Indiana bat, especially information on summer ecology, that has been gathered since 1983; 2) to highlight the continued and accelerated decline of the species; 3) to continue site protection and monitoring efforts at hibernacula; and 4) to focus new recovery efforts towards research to determine the factor or factors causing population declines. Main recovery actions identified in the revised plan are:

- ☞ Conduct research necessary for the survival and recovery of the Indiana bat, including studies on ecology and life history; summer habitat requirements; genetics; potential chemical contamination; and assessments of temperature profiles and hibernation microclimates of major hibernacula.

- ☞ Obtain information on population distribution, status, and trends.

- ☞ Protect and maintain Indiana bat populations.

- ☞ Provide information and technical assistance outreach.

- ☞ Coordinate and implement the conservation and recovery of the Indiana bat.

The Indiana bat is a migratory species found throughout much of the eastern half of the United States (Figures 2 and 3; Table 3). During winter, Indiana bats are restricted to suitable hibernacula (mostly caves, but also a few abandoned mines, and even a tunnel and a hydroelectric dam) that primarily are located in karst areas of the east-central U. S. (Figure 2). More than 85 percent of the range wide population occupies nine Priority One hibernacula (hibernation sites with a recorded population >30,000 bats since 1960 - although two of these currently have extremely low numbers of bats). Indiana, Kentucky, and Missouri each contain three Priority One hibernacula. Priority Two hibernacula (recorded population >500 but <30,000 bats since 1960) are known from the above mentioned states, in addition to Arkansas, Illinois, New York, Ohio, Tennessee, Virginia, and West Virginia. Priority Three hibernacula with recorded populations <500 bats or records of single hibernating individuals have been reported in 17 states, including all of the above mentioned states.

Hibernacula with recorded populations of <500 bats (Priority Three hibernacula) or records of single hibernating individuals have been reported in the above mentioned states plus Alabama, Connecticut, Florida, and Georgia.

Although the number of band returns for the Indiana bat are limited, certain migration patterns may be inferred from what little information that does exist. Based on sparse band recovery records, all of which are from the Midwest, it appears that females and some males migrate north in the spring upon emergence from hibernation (Hall, 1962; Myers 1964; Hassell and Harvey 1965; Barbour and Davis, 1969; Kurta, 1980; LaVal and LaVal, 1980; Bowles, 1982), although there also is evidence that movements may occur in other directions. However, summer habitats in the eastern and southern United States have not been well investigated; it is possible that both sexes of Indiana bats occur throughout these regions. Very little is known about Indiana bat summer habitat use in the southern and eastern United States, or how many Indiana bats may migrate to form maternity colonies there. Most summer captures of reproductively active Indiana bats (pregnant or lactating females or juveniles) have been made between April 15 and August 15 in areas generally north of the major cave areas (Figures 2 and 3). While these observations suggest that many or most female Indiana bats in the Midwest migrate north in the spring and south in the fall, other individuals may potentially migrate in other directions (LaVal and LaVal 1980). Additional work is especially needed to better understand Indiana bat summer distribution.

Most of the maternity records of the Indiana bat originated in the Midwest (southern Iowa, northern Missouri, northern Illinois, northern Indiana, southern Michigan, and western Ohio). The first maternity colony was found and several studies of Indiana bat maternity habitat were

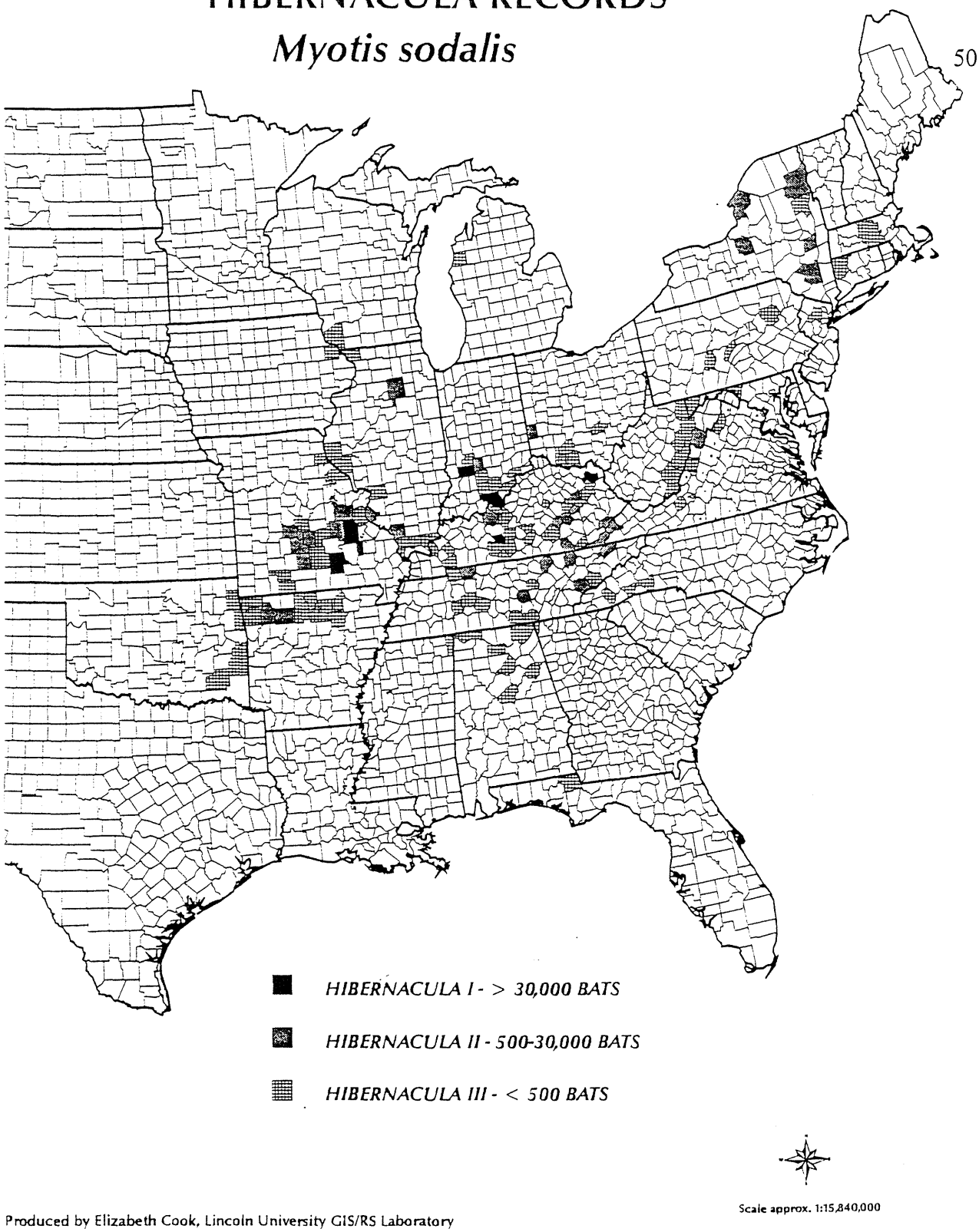
HIBERNACULA RECORDS
Myotis sodalis
50
HIBERNACULA I - > 30,000 BATS
HIBERNACULA II - 500-30,000 BATS
HIBERNACULA III - < 500 BATS
Scale approx. 1:15,840,000
Produced by Elizabeth Cook, Lincoln University GIS/RS Laboratory

Figure 2. Counties with current and historical records of Indiana bat hibernacula (from U.S. Fish and Wildlife Service 1999).

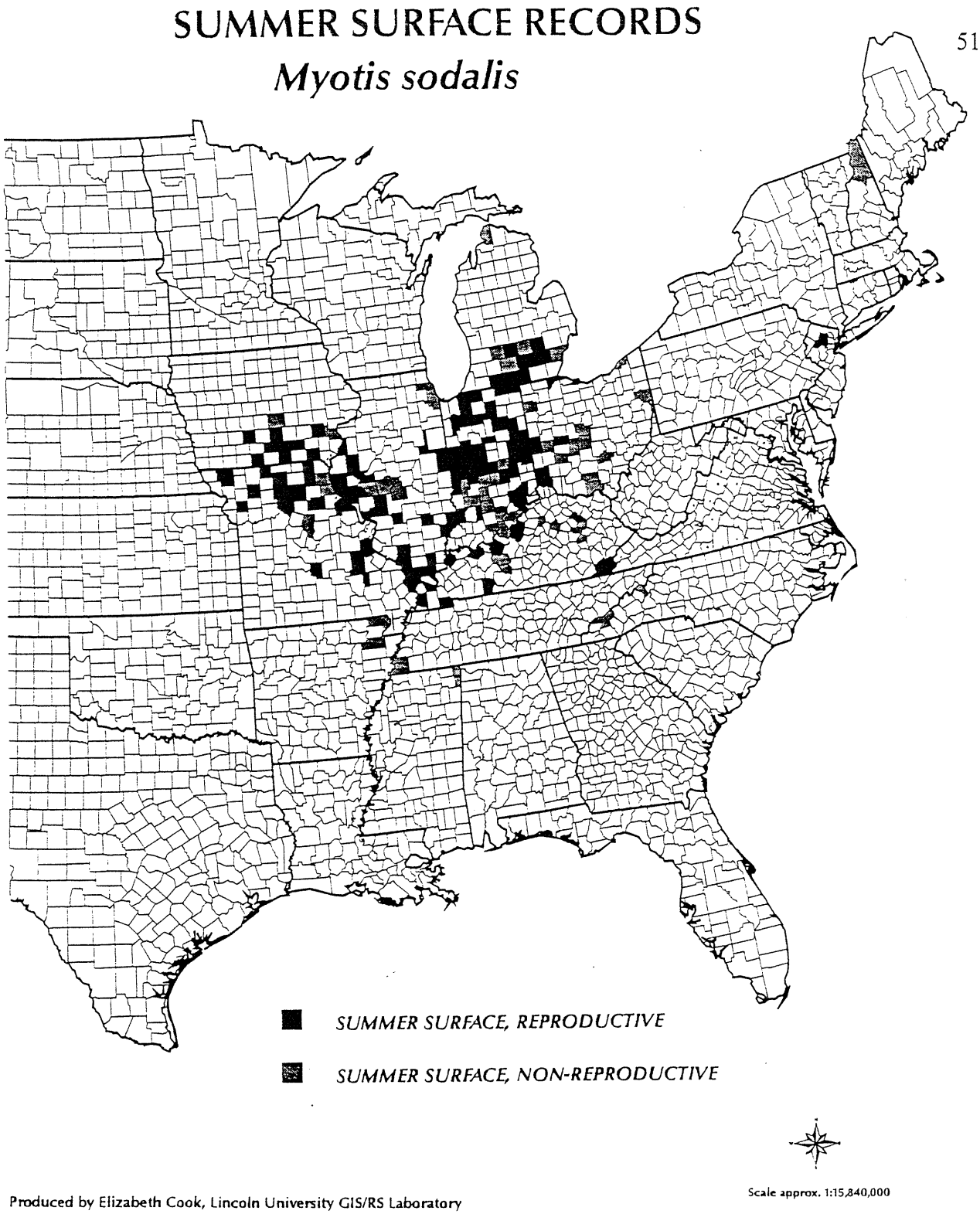

Figure 3. Counties with records of reproductively active (females at maternities or juveniles) and non-reproductively active (males, non-maternal females, or transients) Indiana bats (from U.S. Fish and Wildlife Service 1999).

Table 3. Summary of hibernating Indiana bat populations by State, based upon estimates nearest to year indicated[1,2] (from U.S. Fish and Wildlife Service 1999).

State	Estimated Population		
	Historic Level (1960 or Earliest #)	When Regular Surveys Began (~1980)	Most Recent Survey (1995-1997)
Alabama	300	300	300
Arkansas	14,930	14,830	2,700
Illinois	4,140	3,990	4,530
Indiana	177,885	124,080	182,510
Kentucky	241,335	96,235	61,370
Missouri	323,120	302,915	47,135
New York	7,805	7,805	14,990
Ohio	--	--	9,300
Pennsylvania	65	65	270
Tennessee	19,305	19,305	16,580
Virginia	5,620	5,620	1,840
West Virginia	4,700	4,675	11,660
Total	808,505	589,120	353,185

[1]Due to inconsistent records, population estimates for a particular period were extrapolated from the nearest survey prior to or subsequent to the year displayed in the table; therefore, all caves are represented in each period.

[2]States with records of fewer than 100 hibernating Indiana bats are not listed.

conducted in the Midwest region. Although the woodland in this glaciated region is mostly fragmented, it has a relatively high density of maternity colonies. Today, small bottomland and upland forested tracts with predominantly oak-hickory forest types and riparian/bottomland forests of elm-ash-cottonwood associations exist in an otherwise agriculturally dominated (nonforested) landscape (U.S. Fish and Wildlife Service 1999).

Unglaciated portions of the Midwest (southern Missouri, southern Illinois, southern Indiana), Kentucky, and most of the eastern and southern portions of the species' range appear to have fewer maternity colonies per unit area of forest. However, such conclusions may be premature, given the lack of search effort in these areas.

Male Indiana bats may be found throughout the entire range of the species. Males appear to roost singly or in small groups, except during brief summer visits to hibernacula.

Current status and population trends in hibernacula

Based on censuses taken at hibernacula, the total, known Indiana bat population in 1997 was estimated at 353,000 bats (Table 3). Indiana bat populations first were first surveyed in the late

1950s (Hall, 1962). In the decades since then, additional colonies of hibernating Indiana bats were discovered and our knowledge of the distribution and status of the species has expanded. Many hibernacula populations have decreased in number since monitoring began, especially in Kentucky and Missouri.

More than half of the current population of the Indiana bat hibernates in the nine Priority One hibernacula. Eight of the nine have been surveyed every two years from 1983 to 1998. Due to the previously reported unsafe conditions at Pilot Knob Mine in Iron County, Missouri, this site had not been surveyed for many years. In July 1998, personnel from Bat Conservation International (BCI) in Austin, Texas, conducted an on site inspection of the mine to determine if it was stable enough to conduct a survey for Indiana bats. Although BCI determined that the mine was dangerous, they concluded that it was not hazardous enough to prevent a survey of Indiana bats in some portions of the mine (Schmauch and Tuttle 1998). In February 1999, personnel from BCI returned to the site and conducted a survey for Indiana bats. Only 303 Indiana bats were counted in accessible portions of the mine (Kennedy and Ducummon 1999). Although certain parts of the mine were inaccessible, the low count suggests that the species may be declining at this site as well as elsewhere in Missouri and other areas in the eastern United States. During the period 1983 through 1997, the populations in these caves declined by 38%.

The status of the Indiana bat in the three states with the largest hibernating populations is reviewed below:

Indiana: The known population in Indiana apparently dropped from the earliest known surveys through 1980, but has increased steadily in recent years (Table 3). Indiana now contains half (182,500) of all Indiana bats in existence.

Kentucky: This state has exhibited a significant decline in population numbers of Indiana bat with the loss of an estimated 145,000 bats between 1960 and 1975 (Table 3). Losses at two of the major hibernacula were attributable to microclimate changes due to a poorly designed cave gate at one hibernation site (Humphrey 1978), and the construction of a building over the upper entrance to another (U.S. Fish and Wildlife Service 1999). Although not as dramatic as earlier losses, many of the major remaining hibernating populations have declined steadily during the past 15 years. For reasons not totally understood, populations in west-central, northeastern, and extreme southeastern Kentucky declined between 1960 and 1975, while the populations in east-central and western Kentucky increased.

Missouri: Despite efforts such as the construction of appropriate gates at cave entrances, populations of hibernating Indiana bats in Missouri have declined steadily and drastically since 1980 (Table 3). The colonies of Indiana bats in the two Priority One caves that can be surveyed and 12 of the 13 Priority Two hibernacula in the state have declined during this period. Since 1983, the overall Missouri population has shown a cumulative estimated decline of over 250,000 bats, a loss of more than 80% of the population. The current total estimated population of Indiana bats in the state is less than 50,000 (MDC Natural Heritage Database 1997).

Other states: Among the other states with regularly occurring hibernating populations of Indiana bats, recent trends are mixed (Table 3). Population trends in Alabama, Illinois, Ohio, Tennessee, and Virginia are either not known or are not well documented. Alabama, Illinois, Tennessee, and Virginia do not have enough recent survey information for a trend analysis, and the only known hibernaculum in Ohio was not discovered until the winter of 1995/1996. The population of Indiana bats is apparently declining in Arkansas. The species may be increasing in New York, Pennsylvania, and West Virginia, but complex cave systems such as those at Hellhole Cave in West Virginia and several caves in New York caves make surveying Indiana bats difficult and complicate population trend analysis.

A few Indiana bats have been documented in the winter in Connecticut, Florida, Georgia, Iowa, Maryland, Massachusetts, Michigan, Mississippi, New Hampshire, New Jersey, North Carolina, Oklahoma, South Carolina, Vermont, and Wisconsin (Table 3). However, because most of these records usually involve less than 10 individuals, no regular hibernacula surveys are conducted in these states.

Not all of the causes of Indiana bat population declines have been determined; the decline of the species at its current rate is unknown. Although several known human-related factors have caused declines in the past, they may not solely be responsible for recent declines.

Active programs by state and federal agencies have led to the acquisition and protection of a number of Indiana bat hibernacula. Of 127 caves/mines with populations >100 bats, 54 (43%) are in public ownership or control, and most of the 46 (36%) that are gated or fenced are on public land. Although such conservation efforts that have been successful in protecting Indiana bats from human disturbance, they have not been sufficient to reverse the downward trend in many populations.

Reasons for decline

1. Documented causes.

a. Disturbance and vandalism. A serious cause of Indiana bat decline has been human disturbance of hibernating bats during the decades of the 1960s through the 1980s. Bats enter hibernation with only enough fat reserves to last until spring. When a bat is aroused, as much as 68 days of fat supply is used in a single disturbance (Thomas *et al.*, 1990). Humans, including recreational cavers and researchers, passing near hibernating Indiana bats can cause arousal (Humphrey, 1978; Thomas, 1995; Johnson *et al.* 1998). If this happens too often, the bats' fat reserves may be exhausted before the species is able to forage in the spring.

Direct mortality due to human vandalism has been documented. The worst known case occurred in 1960 when an estimated 10,000 Indiana bats were killed in Carter Cave State Park, Kentucky by three youths who tore masses of bats from the ceiling and trampled and stoned them to death (Mohr, 1972). Another documented incident was reported from Thornhill Cave, Kentucky, where at least 255 Indiana bats were killed by shotgun blasts in January 1987 (Anon., 1987).

b. Improper cave gates and structures. Some hibernacula have been rendered unavailable to Indiana bats by the erection of solid gates in the entrances (Humphrey, 1978). Since the 1950's, the exclusion of Indiana bats from caves and changes in air flow are the major cause of loss in Kentucky (an estimated 200,000 bats at three caves) (U.S. Fish and Wildlife Service 1999). Other cave gates have so modified the climate of hibernacula that Indiana bats were unable to survive the winter because changes in air flow elevated temperatures which caused an increase in metabolic rate and a premature exhaustion of fat reserves (Richter *et al.*, 1993; Merlin Tuttle, Bat Conservation International, in. litt. 1998).

Conversely, an Indiana bat population may be restored if an improper gate is replaced with one of appropriate design, or if air flow is restored. In Wyandotte Cave, Indiana, dramatic population increases followed gate replacement and restoration of traditional air flow (Richter *et al.* 1993). Improved air flow facilitated by the enlargement of an upper level entrance was apparently responsible for a threefold increase in Indiana bat numbers in Ray's Cave, Indiana (Brack *et al.* 1991). The recovery of hibernating populations to historic levels, however, have not been as successful elsewhere. At Hundred Dome Cave, Kentucky, predicted population gains have never been realized, although air flow obstructions have been removed and gates suitable for the species installed (U.S. Fish and Wildlife Service 1999).

c. Natural hazards. Indiana bats are subject to a number of natural hazards. River flooding in Bat Cave, Mammoth Cave National Park, drowned large numbers of Indiana bats (Hall, 1962). Other cases of hibernacula being flooded have been recorded by Hall (1962), DeBlase *et al.* (1965), and U.S. Fish and Wildlife Service (1999). A case of internal cave flooding occurred when tree slash and debris (produced by forest clearing to convert the land to pasture) were bulldozed into a sinkhole, blocking the cave's rain water outlet and drowning an estimated 150 Indiana bats (U.S. Fish and Wildlife Service 1999). One case of flash flooding compounded by cave gates occurred in 1997: in early March, a severe flood occurred in Bat Cave at Carter Caves State Park, Kentucky. Debris that had accumulated on the gate at the upper entrance impounded rain water until pressure destroyed the gate, allowing a surge of water through the cave system where it was backed up again at the gate in the lower cave entrance. Water reached the ceiling in portions of the hibernation section of the cave and drowned an estimated 3,000 Indiana bats (U.S. Fish and Wildlife Service 1999).

Bats hibernating in mines are vulnerable to ceiling collapse (Hall, 1962), and this is a concern at Pilot Knob Mine in Missouri, once the largest known Indiana bat hibernating population. To a lesser extent, ceiling collapse in caves is also possible.

Another hazard exists because Indiana bats hibernate in cool portions of caves that tend to be near entrances, or where cold air is trapped. Some bats may freeze to death during severe winters (Humphrey, 1978; Richter *et al.*, 1993). Indiana bats apparently froze to death in Bat Cave (Shannon County, Missouri) in the 1950s (U.S. Fish and Wildlife Service 1999). The population at this site was 30,450 in 1985, when the bats were observed roosting on a high ceiling, presumably to escape severe cold at their traditional roosting ledges 7-9 ft above the cave floor.

In a subsequent 1987 survey, the population had plummeted to 4,150 bats, and the cave floor was littered with bat bones, suggesting that the bats died during hibernation, apparently freezing to death (U.S. Fish and Wildlife Service 1999).

At Missouri's Great Scott Cave, average mid-winter temperatures appear to have risen 8°F (4.4°C) from the mid 1980s through the present, compared to temperatures in the 1970s and early 1980s; a major population loss occurred between the mid 1980's and 1998. Preliminary analysis of fall and winter temperature data suggests that a similar trend has occurred in ambient temperature outside the cave, and thus appears to have played a role in these population losses (Clawson, pers. observ., July 1998). A much more detailed analysis is needed, along with detailed temperature profiles of this and other hibernacula, to better understand the relationship(s) between climate, air flow, and hibernation microclimates within important hibernacula.

Indiana bats are vulnerable to the effects of severe weather when roosting under exfoliating bark during summer. For example, a maternity colony was displaced when strong winds and hail produced by a thunderstorm stripped the bark from their cottonwood roost and the bats were forced to move to another roost (U.S. Fish and Wildlife Service 1999).

d. Other. Other documented sources of decline include indiscriminate collecting, handling and banding of hibernating bats by biologists, and flooding of caves due to rising waters in reservoirs (Humphrey 1978).

2. Suspected causes.

a. Microclimate effects. Changes is the microclimates of caves and mines may have contributed to the decline in population levels of the Indiana bat than previously estimated (Tuttle, in litt., August 4, 1998). Entrances and internal passages essential to air flow may become larger, smaller, or close altogether, with concomitant increases or decreases in air flow. Blockage of entry points, even those too small to be recognized, can be extremely important in hibernacula that require chimney-effect air flow to function. As suggested by Richter *et al.* (1993) and Tuttle (in litt., August 4, 1998), changes in air flow can elevate temperatures which can cause an increase in metabolic rate and a premature exhaustion of fat reserves.

Hibernacula in the southern portions of the Indiana bat's range may be either near the warm edge of the bat's hibernating tolerance or have relatively less stable temperatures. Hibernacula in the North may have passages that become too cold. In the former case, bats may be forced to roost near entrances or floors to find low enough temperatures, thus increasing their vulnerability to freezing or predation. In the North, bats must be able to escape particularly cold temperatures. In both cases, modifications that obstruct air flow or bat movement could adversely impact the species (U.S. Fish and Wildlife Service 1999).

Recent analysis of mid-winter temperature records obtained during hibernacula surveys, especially of Priority One caves, suggests that unacceptable deviations in roost temperatures may account for some of the overall population decline (Tuttle, in litt., August 4, 1998). Although

scanty, the data suggest that when populations roost mostly at temperatures below 35°F or above 47°F (2°C and 8°C), they usually decline and when roosting between 37°F and 45°F (3°C and 7.2°C) they tend to grow.

To test the hypothesis that changes in the microclimates of Indiana bat hibernation sites may be contributing to the recent downward trend in this species, a project was initiated in the summer of 1998 to investigate the temperature and relative humidity of 13 of the major hibernacula in Indiana, Kentucky, Missouri, Tennessee, and Virginia. Each cave was surveyed and 37 data loggers were installed between July 19 and 29 1998. Investigations revealed that crucial air flow had been interrupted at some sites and the air temperature had risen a few degrees above normal in others, providing additional initial evidence that changes in microclimates may be contributing to this species drastic decline (Tuttle, in litt., August 4, 1998). Additional years of monitoring at these sites will be necessary to further evaluate any changes in hibernation conditions.

b. Land use practices. The Indiana bats' maternity range has changed dramatically since pre-settlement times (Schroeder 1981; Giessman *et al.* 1986; MacCleery 1992; Nigh *et al.* 1992). Most of the forest in the upper Midwest has been fragmented, fire has been suppressed, and native prairies have been converted to agricultural crops or to pasture and hay meadows for livestock. Native species have been replaced with exotics in large portions of the maternity range, and plant communities have become less diverse than occurred prior to settlement. Additionally, numerous chemicals are applied to these intensely cropped areas. The changes in the landscape and the use of chemicals (McFarland 1998) may have reduced the availability and abundance of the bats' insect forage base.

Conversely, regions surrounding hibernacula in the Missouri Ozarks and elsewhere are now more densely forested than they were historically (Marbut 1914; Sauer 1920; Ladd 1991; Nigh *et al.* 1992; Jacobson and Primm 1997). Consequently, the open, savanna-like conditions important to the species maternity habitat (Romme *et al.* 1995) is much less abundant today than occurred historically (U.S. Fish and Wildlife Service 1999).

In the eastern U. S., the area of land covered by forest has been increasing in recent years (MacCleery 1992). Whether or not this is beneficial to the Indiana bat is unknown. The age, composition, and size class distribution of the woodlands will have a bearing on their suitability as roosting and foraging habitat for the species outside the winter hibernation season. A clearer picture of the relationship between the Indiana bat and its summer habitat requirements is urgently needed. An understanding of the factor or factors responsible for the continued decline of the species is needed before it can accurately be determined whether the loss of roosting habitat is limiting to regional or range wide populations of the species (U.S. Fish and Wildlife Service 1999).

c. Chemical contamination. Pesticides have been implicated in the declines of a number of insectivorous bats in North America (Mohr, 1972; Reidinger, 1972, 1976; Clark and Prouty, 1976; Clark *et al.*, 1978; Geluso *et al.*, 1976; Clark, 1981). The effects of pesticides on Indiana

bats have yet to be studied. McFarland (1998) studied two sympatric species, the little brown bat (*Myotis lucifugus*) and the northern long-eared bat (*M. septentrionalis keenii*) as surrogates in northern Missouri and documented depressed levels of acetylcholinesterase, suggesting that bats there may be exposed to sublethal levels of organophosphate and/or carbamate insecticides applied to agricultural crops. McFarland (1998) also demonstrated that bats in northern Missouri are exposed to significant amounts of agricultural chemicals, especially those applied to corn. BHE Environmental, Inc. (1999) collected tissue and guano samples from five species of bats at Fort Leonard Wood, Missouri and documented the exposure of bats to p,p'-DDE, heptachlor epoxide, and dieldrin.

Previous surveys conducted in Missouri to determine the distribution of Indiana bats

Numerous Indiana bat studies have been undertaken in Missouri other than the regularly occurring counts conducted at primarily Priority One and Two hibernacula during the winter hibernation season (U.S. Fish and Wildlife Service 1999). Considerable effort has also been undertaken throughout the state to document the presence of Indiana bats through surveys conducted at potential maternity sites, or at hibernacula during spring and fall (e.g., Myers 1964; Easterla and Watkins 1969; LaVal *et al.* 1976; LaVal *et al.* 1977; LaVal and LaVal 1980; Clawson *et al.* 1986; 3/D International, Inc. 1996; Callahan *et al.* 1997). Myers (1964) banded 21, 321 Indiana bats within the Ozark Plateau, but in addition to the southern Missouri Ozarks, his study area included portions of northwestern Arkansas, northeastern Oklahoma, and west central Illinois. LaVal and LaVal (1980), however, banded approximately 12,000 Indiana bats within the Meramec River Basin.

The magnitude of other surveys conducted, however, is not accurately reflected in the literature because many studies that yielded negative data have not been published (Rick Clawson, pers. commun. February 1999). Although MDC has access to most of the raw data, no previous attempt has been made to enter it into a database where it can be used to depict areas pictorially or to calculate the amount of effort extended.

Recently, data on all known surveys conducted in the state were entered into a database and then exported into a GIS file where they could visually portrayed. Locations of Indiana bat captures, maternity roost trees, and areas where no bats where captured are shown in Figure 4. Surveys have been conducted in every county north of the Missouri River with the exception of St. Charles and Warren counties. Efforts south of the Missouri River to date have concentrated in the Big River/Meramec River basins, Fort Leonard Wood, and on the Houston/Rolla and Doniphan/Eleven Point districts of the MTNF. All known Indiana bat maternity roost trees and 71% of all known records of reproductively active females (i.e., either lactating or post lactating individuals) have been recorded in the northern three tiers of counties in the state (Figure 4). The presence of five records of reproductively active females in Iron, Jefferson, Pulaski, and Washington counties, suggest that maternity colonies are possible in the Ozark region of the state (Figure 4). Additionally, some male Indiana bats are likely to remain during the summer months at most hibernacula in the state and are possible probably throughout much of the state during spring and fall migration (U.S. Fish and Wildlife Service 1999) as documented in Figure 4.

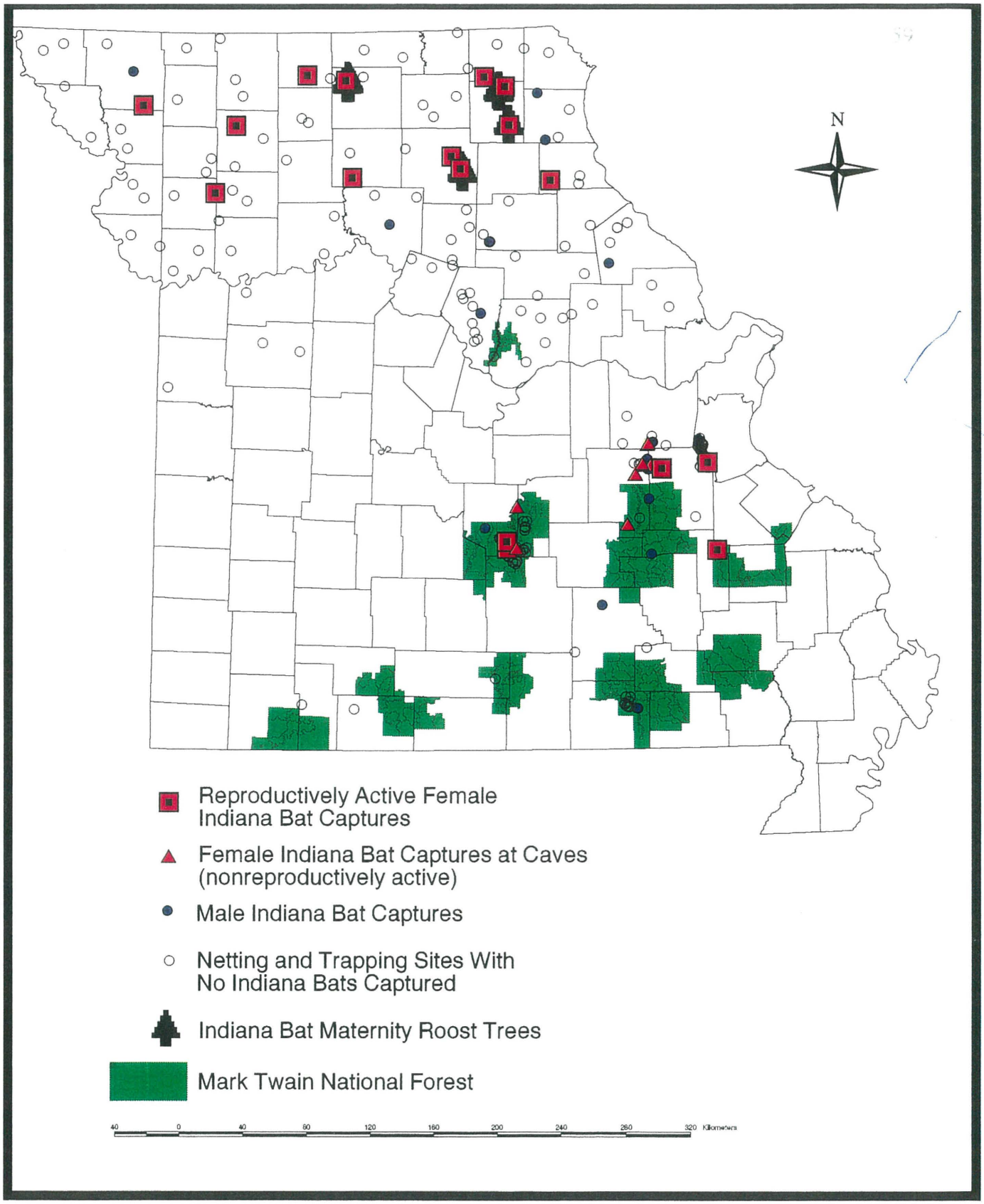
N
Reproductively Active Female Indiana Bat Captures
Female Indiana Bat Captures at Caves (nonreproductively active)
Male Indiana Bat Captures
Netting and Trapping Sites With No Indiana Bats Captured
Indiana Bat Maternity Roost Trees
Mark Twain National Forest
40 0 40 80 120 160 200 240 280 320 Kilometers

Figure 4. Locations of Indiana bat captures (reproductively active and non-reproductively active females, males), known Indiana bat maternity roost trees, and sites where no bats were captured during surveys conducted in Missouri between 1964 and 1998 (MDC unpubl. data).

Catch per unit effort for surveys were calculated by dividing the total amount of time in hours by the total number of bats captured. The number of bats captured per site were calculated by dividing the total number of bats captured by the number of sites. Because it would be much easier to catch an Indiana bat with a mist net at the entrance of a known hibernaculum compared to over a stream, catch per unit effort and catch per site were calculated separately for cave and non-cave sites. Results are presented in Table 4.

Surveys conducted at 19 cave entrances yielded 23.01 bats/hr and 279.90 bats/site. The fact that bats were more difficult to capture at the 265 non-cave sites (Figure 4) scattered across the state, as expected, is reflected in the low capture rate of 0.12 bats/hr and 0.57 bats/site (Table 4).

Table 4. Number of sites, Indiana bat captures, hours of effort, bats/hour, and bats/site for surveys conducted at caves and non-cave locations in Missouri between 1964 and 1998 (MDC unpublished data).

Type of Site	Number Of Sites	Number of Indiana Bats Captured	Effort (hrs.)	Bats/hr.	Bats/site
Non-cave[1]	265	151	1,224	0.12	0.57
Cave	19	5,318	231	23.01	279.90

[1] Mostly over stream and/or river corridors but includes a few upland non-riparian corridor sites.

C. Status of the species within the action area

The only two active (i.e., with records within the last 25 years) hibernacula on the MTNF are Cave Hollow Cave in Iron County and White Creek's Cave in Oregon County (Figure 5). During the most recent census (1998), 21 Indiana bats were recorded in White Creek's Cave and 79 individuals were counted in Cave Hollow Cave (Clawson, pers. commun. 1998).

In 1997 and 1998 mist nets and harp traps were used to survey Indiana bats on portions of the Houston/Rolla and Doniphan/Eleven Point districts. In 1997, no Indiana bats were captured during 95 hours of effort between June 7 and August 6. No Indiana bats were caught using mist nets during 123.5 hours of effort between June 12 and August 8, 1998. Harp traps were used at Cave Hollow Cave September 9, 10, and September 30 (12.5 hours of effort) and 3 male Indiana bats were captured on September 30. Three hours of effort using a harp trap at White Creek's Cave on October 14, 1998 yielded one male Indiana bat (Eberly, in litt. March 3, 1999).

Although no reproductively active female Indiana bats have been found to date on the MTNF, the

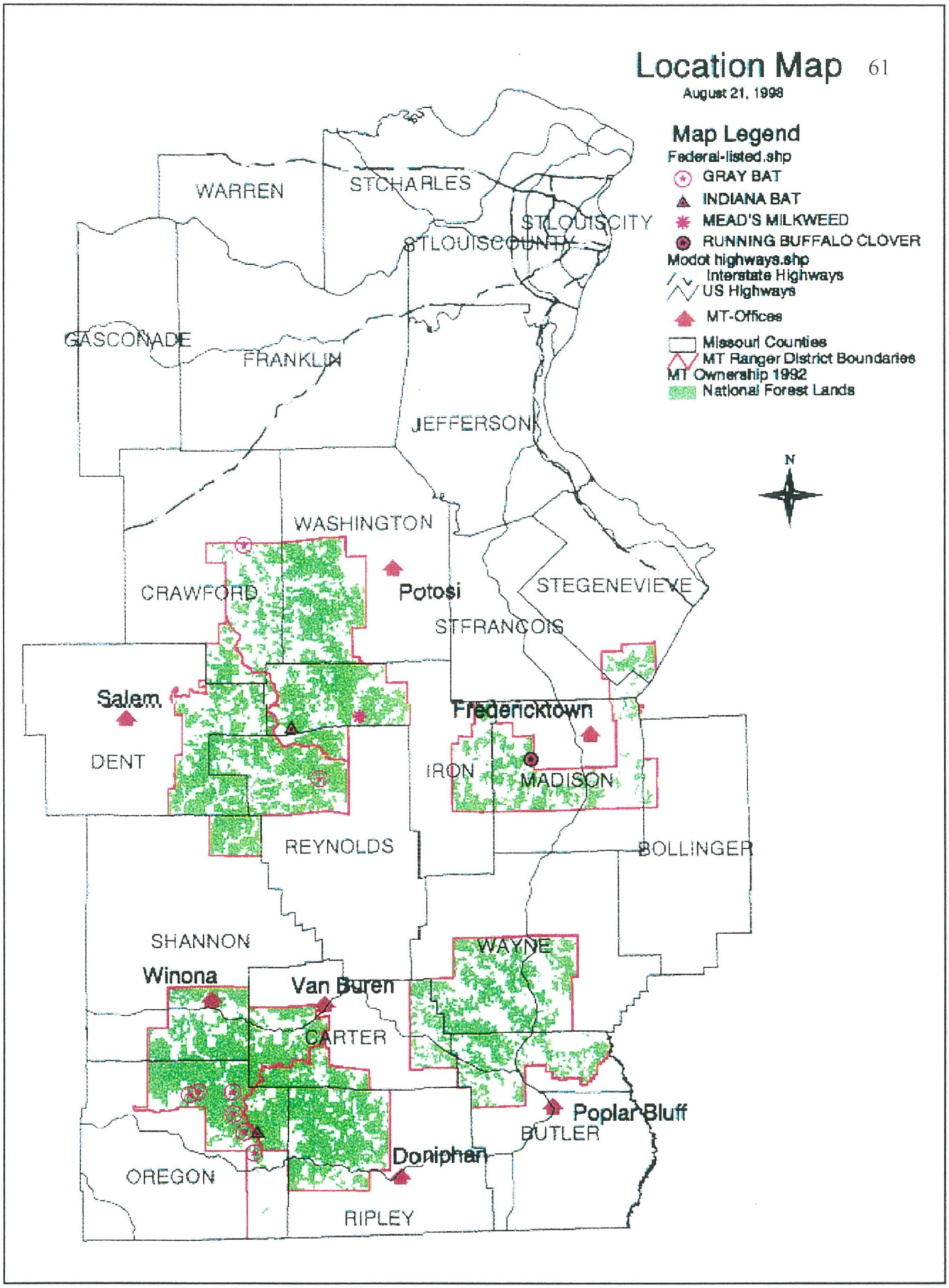

Figure 5. Locations of active Indiana bat hibernacula on the Mark Twain National Forest, Missouri.

capture of two reproductively active females on Fort Leonard Wood adjacent to the MTNF in Pulaski County in 1995 by 3D/International, Inc. (1996) suggests that maternity colonies are still possible on National Forest land. Using the largest population counts ever recorded for White Creek's Cave (1990) and Cave Hollow Cave (1988), the U.S. Forest Service (1998) estimated that a maximum of approximately 300 Indiana bats occurred in these two hibernacula. Given the fact that: 1) male Indiana bats may remain near other occupied hibernacula on lands adjacent to MTNF and could forage on nearby National Forest lands, 2) two records of reproductively active females (with a potential of two colonies at approximately 100 bats per colony) on Fort Leonard Wood suggest that surrounding National Forest land may possibly be used by additional Indiana bats, and 3) the Cedar Creek District is north of the Missouri River and contains potential maternity habitat, the Service would predict that up to an additional 200 Indiana bats could potentially use National Forest land between the spring-fall period. If such a hypothesis was correct, the 500 bats would constitute about 1.06% of the total population of Indiana bats in Missouri and about 0.14% of the entire population in the United States.

D. Effects of the action (direct and indirect effects)

Direct effects

Direct impacts to the Indiana bat could occur as the MTNF continues to implement its forest-wide management activities. The main potential direct effects to Indiana bats on the MTNF would be: 1) the removal of potential roost trees used by a maternity colony (if such colonies do in fact occur on National Forest Land), summering males adjacent to active hibernacula, migrants during spring and fall migration, or males and females during the fall swarming period, and 2) adverse impacts from prescribed fires on the occasions listed above when bats are using trees for roosting, or when prevailing winds drift smoke into occupied hibernacula.

Direct impacts to the Indiana bat may result in direct mortality or injury to individuals or small groups of roosting bats during the felling of trees that may harbor undetected roosts, or the accidental felling of occupied snags, shagbark hickories, or damaged or hollow trees during timber harvest or other tree removal activities. The likelihood of cutting a tree containing a maternity colony or individual roosting Indiana bat, however, is anticipated to be extremely low because of the large number of suitable roost trees present on the MTNF, the rarity of the species, and the wide dispersal of Indiana bats and maternity colonies throughout the species' range. Other direct effects could result if the harvesting of hardwood and hardwood/pine habitat cause bats in a roosting or maternity colony to abandon a traditionally used site. Additional stress could be placed on pregnant females that are already expending energy. Lower reproductive success or lower survival of young could also result with forced abandonment of lactating females from occupied roosts.

However, implementation of the terms and conditions associated with the reasonable and prudent measures provided below by the Service, will minimize direct adverse effects to the Indiana bat by maintaining suitable Indiana bat roosting and foraging habitat and protecting Indiana bats from the potential effects of timber harvest and other tree removal activities.

Prescribed fires conducted during the Indiana bat summer season could result in direct mortality due to the actual roost tree being incinerated (especially non-volant young at a maternity colony) or adverse effects caused by smoke inhalation (Elder and Gunier, 1981). The MTNF currently burns approximately 4,500 acres per year and prescribed fires usually occur during the spring and fall when Indiana bats are migrating, using habitat adjacent to White Creek's and Cave Hollow caves, or using habitat in areas adjacent to locations in Pulaski County where data currently suggests that a maternity colony may be present. Implementation of the terms and conditions associated with the reasonable and prudent measures provided below by the Service, however will minimize potential direct adverse effects to the species.

Additionally, prescribed fires will provide some beneficial effects to the species by opening closed forest canopies, and by decreasing dense understory vegetation that can inhibit movements to foraging habitats and roosting sites.

The greatest potential for impact to the species would be in areas near the two active Indiana bat hibernacula (i.e., White Creek's Cave and Cave Hollow Cave- Figure 5), areas of the MTNF near other occupied hibernacula on land adjacent to the MTNF, areas on the MTNF in Pulaski County that surround locations of two reproductively active females captured on Fort Leonard Wood, and National Forest land on the Cedar Creek District north of the Missouri River that contains potential maternity habitat. Impact from timber harvest undertaken on the Cedar Creek District, however, is likely to be minimal for the following reasons: 1) only uneven-aged management is used, 2) on average only about 75-125 acres are harvested annually, and 3) the Forest Service has agreed to: a) retain all shagbark and shellbark hickory trees regardless on size, and b) retain all trees greater than 9" dbh that have 10% or more exfoliating bark.

Because both White Creek's Cave and Cave Hollow Cave have protective gates and are monitored by personnel of the MTNF during hibernation season to detect unauthorized entry (U.S. Forest Service 1998), any direct effects from human disturbance at these caves are not anticipated.

Implementation of the terms and conditions associated with the reasonable and prudent measures provided below by the Service, will ensure an abundance of roosting and foraging habitat.

Indirect effects

Indirect effects are defined as those that are caused by the proposed actions and are later in time, but still are reasonably certain to occur (50 CFR 402.02). The main potential indirect effects to the Indiana bat on the MTNF would be: 1) a potential reduction in the species' forage base due to the loss of foraging habitat, and 2) loss of the species' prey base due to the degradation of water quality of streams and rivers within riparian corridors over which the species forages that could negatively impact the emergence and abundance of insects within such corridors.

Forest management activities which (either temporarily or permanently) reduce forest canopy closure to less than 30% (i.e., certain types of timber harvest, new road construction, and new

utility corridors) could potentially reduce the availability and/or suitability of those areas as Indiana bat foraging habitat. It is believed, however, that potential adverse impacts to the species due to indirect effects is expected to be remote for the following reasons:

- Standards and guidelines outlined in the LRMP for the MTNF provide significant protection for riparian corridors on the National Forest. Management activities in these areas are either limited or prohibited. The lack or restriction of management activities within riparian corridors will enable the ecological integrity of these areas to be maintained into the foreseeable future.

- The minor reductions in available foraging habitat in some areas would be offset by the creation of suitable Indiana bat foraging habitat through other forest management activities.

- Extensive research indicate that this species forages over a wide range of habitats including riparian corridors, upland areas, fields, shelterwood cuts, and other disturbed areas (U.S. Fish and Wildlife Service 1999).

- The species is considered a foraging generalist that will take advantage of prey from numerous types of forest conditions; an abundance of insect prey is likely to be available throughout the MTNF during the spring-fall periods for the few Indiana bats that have been documented on the MTNF

- The opening of the forest canopy in certain situations [i.e. mature forest where the canopy closure is greater than the 60-80% recommended by Romme et al. (1995)] would undoubtedly increase habitat diversity and therefore insect abundance.

The U.S. Geological Survey conducted an extensive water quality study of the Ozark Plateaus in Arkansas, Kansas, Missouri (including basins that cover National Forest land in most districts of the MTNF), and Oklahoma between 1992 and 1995, and concluded that the water quality was well within acceptable levels for several parameters established by EPA (Petersen *et al.* 1998). Sedimentation, however, was not included in their analysis.

Although the impacts of siltation on aquatic insects has not been thoroughly studied, Tuttle (1979) noted that none of the five gray bat colonies that he studied that remained stable between 1970 and 1976 foraged over heavily silted waterways. Excess sedimentation in streams, rivers, and lakes on the MTNF could originate from several sources: 1) timber harvest operations, 2) road construction and maintenance, 3) runoff following prescribed fires, 4) overgrazing which could accelerate erosion, and disturbance from ATVs, motor bikes, cattle, and horses, especially within riparian corridors. Adverse impacts from siltation is likely to be minimal because very little management is undertaken within riparian corridors, and standards and guidelines outlined in the LRMP for the MTNF implement steps that minimize soil erosion and maintain good water quality.

It is highly unlikely that the use of herbicides on the MTNF contributes to the potential loss of prey base for Indiana bats for the following reasons: 1) use is extremely limited and is only applied to approximately 120 acres per year, 2) what limited application that is done is conducted in areas that receive little use from Indiana bats (i.e., around buildings, open fescue fields), 3) application is constrained near bat caves and riparian corridors, and 4) host specific herbicides would have negligible effects on insects utilized by Indiana bats because herbicides are usually applied directly to a target plant and any impact to non-target insects during application would be minimal and short lived; additionally, if applicable, the application of herbicides would impact a minute amount of vegetation that could serve as food for larval stages of insects that this species forages on.

The incorporation of the terms and conditions associated with reasonable and prudent measures requested by the Service below will further minimize the impacts of any potential adverse direct and indirect effects.

E. Cumulative effects

Cumulative effects include the combined effects of any future State, local, or private actions that are reasonably certain to occur within the action area covered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA. Additionally, any future Federal, State, local, or private actions that are reasonably certain to occur in the action area, and which are considered in this biological opinion, will either be carried out by, or will require a permit from, the Forest Service; they will, therefore, require compliance with Section 7 of the ESA. Because the Service is not aware of any future State, local, or private actions that are reasonably certain to occur within the action area and which would not be subject to Forest Service Section 7 review, cumulative effects, as defined by the ESA, will not occur and will not be addressed further in this opinion.

F. Potential interrelated and interdependent actions

The Service is aware of the suggestions of some that the operation of chip mills outside of the boundaries of the MTNF should be included in an analysis of interrelated and/or interdependent actions associated with the proposed action. An interrelated activity is an activity that is part of the proposed action and depends on the proposed action for its justification (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998). An interdependent activity is an activity that has no independent utility apart from the action under consultation (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998). An analysis of whether other activities are interrelated to, or interdependent with, the proposed action under consultation should be conducted by applying a "but for" test. That is, it must be determined that the other activity under question would not occur "but for" the proposed action under consultation (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998). In the case of the chip mills mentioned above, a determination would need to be made that chip mills would not have come into existence had it not been for the presence of adjacent Forest Service land, before such actions could be considered as interrelated or interdependent, and therefore, considered in this opinion.

However, since there is no justification for claiming that chip mills came into existence due to the presence of the MTNF, their operation outside the boundaries of the National Forest can not be considered as an interrelated or interdependent action that should be considered in this opinion.

Some have also argued that the "but for" analysis is applicable in the present example because the loss of forest land outside the boundaries of the Mark Twain National Forest due to chip mill operations using timber on private property would place a greater demand for timber harvest on Forest Service land. The Service disagrees with this assertion, however, because incidental take involving Indiana bats in this opinion is partially in the form of acreage, and any harvest above that level would necessitate the reinitiation of formal consultation. Because such reinitiation would result in the cessation of all activities until the completion of formal consultation (see Reinitiation Notice below), it is unlikely that this would occur. Consequently, the Service concludes that it is inappropriate to consider the operation of chip mills outside the boundaries of the MTNF as interrelated or interdependent actions associated with the proposed action.

G..Cumulative impact of incidental take anticipated by the Service in previously issued biological opinions

In reaching a decision whether the continued implementation of activities outlined in the LRMP on the MTNF is likely or not likely to jeopardize the continued existence of the Indiana bat, the Service must factor into its analysis previous biological opinions issued involving the species, especially for those opinions where incidental take was presented as the number of acres impacted. Although there have been a few previously issued biological opinions that involve the loss of riparian corridors or foraging and roosting habitat for the Indiana bat (e.g., construction of a reservoir involving the Army Corps of Engineers in Marion, Illinois- John Blankenship, U.S. Fish and Wildlife Service, Fort Snelling, Minnesota, in litt. 1995), most involve activities implemented from Land Resource Management Plans on National Forests in the eastern United States. Additionally, such opinions also involve the potential impact to the largest acreage of Indiana bat roosting and foraging habitat. All previously issued Service biological opinions involving the Indiana bat have been non-jeopardy. In assessing the potential cumulative effects of such previously issued opinions, the following must be included in the analysis:

- The annual removal (in acres) of potential roost trees and/or foraging habitat on the National Forest under review,

- An estimate on the number of Indiana bats likely to be impacted within the action area,

- The amount of acreage remaining of suitable roosting and foraging habitat for Indiana bats following removal- such habitat must be of sufficient age (usually > 50-70 years, depending on growth rates, site characteristics, etc.), size (9-16" + dbh), have those species of trees which have been proven to consistently be suitable for roosting, and an acceptable canopy closure for suitable foraging (as summarized in Romme *et al.* 1995).

To date, the Service has issued final non-jeopardy biological opinions for the following National

Forests:

Cherokee, Daniel Boone, George Washington/Jefferson, Ozark/St. Francis, and Ouachita.

Parameters mentioned above for the five National Forests where biological opinions have been finalized are provided in Table 5.

The cumulative impact of an annual allowable incidental take of 72,300 acres on these five National Forests and its potential impact to Indiana bat must be estimated within the context of: 1) the remaining surrounding landscape that provides suitable foraging and roosting habitat for the species, 2) the conservation measures incorporated into a particular Forest's management plan to minimize the impact of tree removal, 3) the terms and conditions associated with the reasonable and prudent measures provided by the Service in their non-jeopardy biological opinions for each perspective forest that minimize the impact of incidental take, and 4) what percent of the rangewide population is predicted to be impacted by the proposed actions.

The degree that the remaining surrounding landscape provides suitable foraging and roosting habitat for the Indiana bat may be analyzed by estimating the average number of suitable roost trees per acre [i.e., the number of snags, dead or dying trees with at least 10% exfoliating or defoliating bark with a dbh of ≥ 9-16" dbh and those which are Class 1 or Class 2 trees as summarized by Romme *et al.* (1995), den or cull trees, lightning struck or otherwise injured trees ≥9" dbh, live shell bark and shagbark hickories ≥9" dbh, and live trees ≥26" dbh], and the number of acres of suitable foraging habitat. Based on the information from several sources (e.g., Shifley *et al.* 1997; Houf, pers. commun., March 1999; MacGregor, pers. commun, March 1999; Randy Jensen, MDC, Ellington, Missouri, in litt. March 8, 1999), it has been estimated that the average forest in the eastern United States > 50 years old, would contain at least 20 trees per acre that provide suitable roosting habitat for Indiana bat.

The 3,109 [3] (Table 5) Indiana bats estimated above would constitute approximately 7/8 of 1% (i.e., 0.87%) of the entire population in the eastern United States. Although a much smaller percentage of the 3,109 individuals would be present during the summer, many of these bats could be present on these National Forests during spring and fall migration. Assuming that the bats listed above are possibly dispersed throughout the five National Forests for the which final opinions have been issued, and in the absence of any conservation measures provided by the Forest Service or reasonable and prudent measures provided by the Service, the amount of acres of suitable habitat and the number of suitable roost trees available to each bat on each National Forest are provided in Table 5. The figures indicate that the number of suitable roost trees available to each individual Indiana bat on the five National Forests ranges from a low of 8,440 trees on the Daniel Boone to a high of 1,810,640 trees per bat on the Ouachita National Forest.

[3]Actual numbers are much lower- this estimate was partially determined based on predictions made by MacGregor, pers. commun, March 3, 1999.

Table 5. Annual allowed incidental take (acres), estimated number of Indiana bats potentially affected, and acres of suitable roosting and foraging habitat, and number of suitable roost trees remaining following tree removal as identified in biological opinions previously issued by the Service involving five National Forests in the eastern United States.

Forest	Incidental Take (acres)	Estimated Number of Indiana bats Potentially Affected	Acres of Suitable Habitat Remaining	Number of Acres of Suitable Habitat Available To each Bat	Number of Suitable roost Trees Available To each Bat
Cherokee	1,300	~ 200[1]	513,250	2,566	51,320
Daniel Boone	4,500	~ 1,600[1]	~675,000	422	8,440
George Washington/ Jefferson	4,500	~ 300[2]	1,433,974	4,780	95,600
Ozark-St. Francis	19,000[3]	~ 1,000	862,400[3]	862	17,240
Ouachita	43,000	~ 9	814,792[3]	90,532	1,810,640
Totals	29,300	~ 3,109 ??	4,299,416		

[1]MacGregor, pers. commun., March 3, 1999

[2] Estimate based on MacGregor's predictions for the number of Indiana bats that may occur on the Cherokee and Daniel Boone NF's.

[3]This includes hardwoods, pines, and pine/hardwoods- all of which can provide suitable roosting habitat for Indiana bat.

The figures provide strong evidence that an abundance of roosting habitat will be available to each individual bat that occurs on each National Forest, even following the annual incidental take of acreage as outlined in the Service's biological opinions. Because the species is known to forage over a wide range of habitats, the acreage available to each bat as provided in Table 5 would also provide an abundance of suitable foraging habitat.

Additional conservation measures provided by the Forest Service or reasonable and prudent measures provided by the Service in its biological opinion to minimize the impact of the annual allowable take for each National Forest is summarized below.

Cherokee: the annual incidental take of 1,300 acres identified in the Service's biological opinion

issued in February 1997, is one-fourth of one percent (0.25 %) of the total area of the Cherokee National Forest (CNF) that is suitable for timber harvest. Although there are no documented records of either wintering or summering individuals on the CNF, the Forest is within the migrational range of colonies that hibernate in nearby caves and there is an abundance of suitable roosting habitat that could be used by Indiana bats during the spring-fall period. Consequently, MacGregor believes that as many as 200 Indiana bats are possibly distributed throughout the Forest (MacGregor, pers. commun., March 3, 1999).

The following activities outlined by the CNF's biological assessment of September 3, 1996 provides additional suitable roosting habitat for Indiana bats within areas scheduled for management: 1) the primary harvest technique is a two-aged shelterwood method that leaves a typical residual basal area of 15 to 35 square feet per acre, or approximately 40-60 trees per acre in a size class equal or greater than 9" dbh, 2) 12,664 acres previously considered for harvest were designated as old growth to benefit the black bear, 3) at least 20% of harvestable timber 61 years or older must be retained within each compartment scheduled for management, and 3) the retention of at least two snags, preferably large diameter hardwood snags, in areas harvested.

The primary term and condition associated with reasonable and prudent measures outlined in the Service's opinion that ensure additional roosting habitat on the CNF is that the retention of 20-40 trees per acre of two-aged shelterwood consist of Class 1 or Class 2 trees as identified by Romme *et al.* (1995).

Daniel Boone: the annual incidental take of 4,500 acres provided in the Service's biological opinion issued on April 4, 1997 constitutes approximately three-fourths of one percent (0.75 percent) of the total area of the Daniel Boone National Forest (DBNF) that is suitable for timber production. MacGregor (pers. commun., March 3, 1999) estimates that as many as 1,600 Indiana bats may occur on the DBNF. In their biological evaluation (Forest Service in litt. October 6, 1996) which was the basis for initiating formal consultation with the Service, the DBNF agreed to implement several prudent measures that would provide roosting and foraging habitat for the Indiana bat. Included in these were: 1) the retention of all dead and dying potential "Class 1 or Class 2" trees (after Romme *et al.* 1995) of 16" dbh or greater, 2) the retention of all shagbark and shellbark hickory, and all hollow or cull trees of other species where possible, 3) the retention of at least 16 Class 1 and/or Class 2 trees with a dbh greater than 9", 4) allowance of no more than 40 acres per square mile per decade of regeneration harvest within one-mile radius of each significant cave or hibernaculum, and 5) the retention of residual trees with a basal area of 50 in strips or clumps.

Terms and conditions associated with reasonable and prudent measures in the Service's opinion included: 1) the retention of at least three natural or created snags with a dbh greater than 9" in each harvest area, 2) appropriate numbers of live trees will be left within a 25-foot radius of one-third of all large snags with a dbh greater than 12" dbh to provide shading for potential roosts, 3) clumps of trees are to be left in the harvest area and irregular strips of trees extending into the harvest area to maintain forest travel corridors between the harvest area and surrounding areas, 4)

retention of all shagbark and shellbark hickories, and 5) the retention of all additional reserve trees that have developed exfoliating bark as the result of natural or man-made damage.

George Washington and Jefferson: the annual incidental take of 4,500 acres provided in the Service's biological opinion issued on September 16, 1997 constitutes approximately three-tenths of one percent (0.30 percent) of the total area of the George Washington/Jefferson National Forests (GWJNFs) that is suitable for timber production. Although to date only seven summer ♂♂ away from hibernacula on the GWJNFs have been located, one was a juvenile ♂ captured on July 28, 1992, suggesting the possibility of a maternity colony on or adjacent to National Forest land. Recently, only 70-90 Indiana bats have been documented at hibernacula on the GWJNFs, but a number of hibernacula are adjacent to National Forest land. Thus, it is possible that as many as 300 Indiana bats could use the GWJNFs during the spring-fall period.

In an attempt to address new information collected on the this species' habitat requirements during the spring-fall non-hibernating period, the GWJNFs developed an Indiana Bat Recovery Strategy (IBRS) (John Wolfin, U.S. Fish and Wildlife Service, Annapolis, MD, in litt. September 16, 1997). In their IBRS, the GWJNFs agreed to provide the following: 1) a no disturbance primary buffer of at least 0.5 miles will be placed around each Indiana bat hibernaculum, 2) a limited disturbance buffer of at least 1.5 miles will be placed around each Indiana bat hibernaculum; within this buffer either: a) a minimum of 20 trees per acre in the 10-16" dbh class and 15 trees per acre with a dbh of 20" or greater must be retained, or b) 60% of the area must be maintained in an age class of 70 years or older; and 40% of oaks, hickories, and yellow poplar (*Liriodendron tulipifera*) must be maintained in an age class of 80 years of age or older, 3) a 1/4 mile no disturbance buffer would be placed around all located roost trees, 4) all shagbark hickory and snags will be retained on the GWJNFs for non-cave roosts, 5) 40% of oaks, hickories, and yellow poplar must be maintained in an age class of 80 years of age or older for non-cave roosts forest wide, and 6) a minimum of 60% of the acreage of all forest types combined on the GWJNFs will be maintained over 70 years of age.

Terms and conditions associated with reasonable and prudent measures in the Service's opinion above and beyond those agreed to by the GWJNFs included: 1) the retention of at least six snags or cavity trees per acre with a dbh of 9" or greater for all timber activities, and 2) the retention of all shagbark hickories throughout the GWJNFs.

Ozark-St. Francis: the annual incidental take of 19,000 acres (8,000 acres of hardwoods and 11,000 acres of pine and pine/hardwood forest types) provided in the Service's biological opinion issued on June 25, 1998 constitutes approximately 8.7 % of the total area of the Ozark-St. Francis National Forest (OSFNF) that is suitable for timber production.

The following activities outlined by if the LRMP for the OSFNF and the biological assessment of October 28, 1997 provides additional suitable roosting habitat for Indiana bats within areas scheduled for management: 1) at least two dead snags greater than 12" dbh (when possible) per acre are retained in all harvested areas, 2) all standing dead trees with exfoliating or defoliating

bark and den trees are retained within riparian corridors, and 3) approximately 147,364 acres are designated old growth (~ 13 %) that have more than 10 individual live trees per acre that are over 120 years old or that are over 22" dbh.

The primary term and condition associated with reasonable and prudent measures in the Service's biological opinion that ensures the availability of suitable roost trees above and beyond those agreed to by the OSFNF is the retention of at least six snags or cavity (Class 1 or Class trees as identified in Romme *et al.* 1995) trees per acre with a dbh of 9" or greater for all timber activities.

Ouachita: the annual incidental take of 43,000 acres provided in the Service's biological opinion issued on April 26, 1999 constitutes approximately 4.8 % of the total area of the Ouachita National Forest (ONF) that is suitable for timber production.

The following activities outlined by if the LRMP for the ONF provides additional suitable roosting habitat for Indiana bats within areas scheduled for management: 1) large den trees (≥18" dbh) will be retained wherever they occur, 2) retain at least two snags per acre, with a minimum of 12" dbh with an objective of ≥16" dbh in regeneration areas, and 3) retain or develop mature growth hardwood habitat (≥100 years old) and mature growth pine habitat (≥ 80 years old) within each project area at a rate of 5 % each. Above and beyond the standards and guidelines outlined in the LRMP for the ONF, the following terms and conditions associated with the reasonable and prudent measures provided in the Service's non-jeopardy biological opinion will afford additional foraging and roosting habitat for the 9 Indiana bats documented on the National Forest: 1) provide a no disturbance buffer consisting of a radius of 0.5 miles around each occupied Indiana bat hibernaculum, and 2) provide a secondary buffer consisting of a radius of 1.5 miles around each occupied Indiana bat hibernaculum where limited management activities will occur.

As with the other National Forests where the Service has issued non-jeopardy biological opinions, an abundance of suitable roosting and foraging habitat will be available to the few Indiana bats using the Ouachita National Forest.

Given: 1) the conservation measures outlined in a National Forest's LRMP, biological assessment, biological evaluation, or recovery strategy developed for the Indiana bat, 2) the additional terms and conditions associated with the Service's biological opinion, 3) the abundance of available, roost trees on the National Forests discussed above, and 4) the small percentage of the overall population of the species likely to be affected from the annual, allowable level of incidental take, the Service believes that potential impacts to the species have been sufficiently minimized to prevent a significant, cumulative reduction in population numbers of the Indiana bat.

H. Conclusion

After reviewing the current status of Indiana bat; the environmental baseline for the action area; the effects of forest management and other activities on the MTNF (both direct and indirect); additional measures identified in the Forest Service's BA to assist in the protection, management,

and recovery of the species; previously issued Service non-jeopardy biological opinions that allow various levels of incidental take; any potential interrelated and interdependent actions associated with the proposed action; and any potential cumulative effects, it is the Service's biological opinion that forest management and other activities authorized, funded, or carried out by the MTNF, are not likely to jeopardize the continued existence of the Indiana bat. Of the six caves in Missouri designated as critical habitat, none are owned by the MTNF and none will be adversely affected by the continued implementation of the LRMP.

I. Incidental take statement

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act, prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns, including breeding, feeding, or sheltering. Harass is defined the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of Section 7(b)(4) and Section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are **non-discretionary**, and must be undertaken by the Forest Service (MTNF) so that they become binding conditions of any grant or permit issue to an applicant, as appropriate, for the exemption of Section 7(o)(2) to apply. The Forest Service (MTNF) has a continuing duty to regulate the activity covered by this incidental take statement. If the Forest Service (MTNF) (1) fails to assume and implement the terms and conditions, or (2) fails to require an applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of Section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Forest Service must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement [50 CFR § 402.14(i)(3)].

J. Amount or extent of incidental take anticipated

The Service anticipates that incidental take of Indiana bats as a result of forest management activities or other actions implemented on the MTNF will be difficult to quantify and detect due to the bat's small body size, formation of small (i.e., 50 or fewer to 100 individuals), widely dispersed colonies under loose bark or in cavities of trees, and unknown areal extent and density of their summer roosting populations range within the MTNF. However, any incidental take of Indiana bats is expected to be in the form of killing, harming, or harassing. Tree removal during the non-hibernation season for harvest or in preparation for other activities may result in mortality to females and young, or to individually roosting Indiana bats, if a particular tree which is

removed contains a maternity colony or roosting bats. If an occupied roost tree is accidentally removed and the bats using it were not killed during removal, the colony (or roosting individuals) would be forced to find an alternate roost. Depending on the circumstances (e.g., alternate roosts are not available or bat/s are required to fly significant distances to locate additional, suitable roost sites), the loss of a single, occupied roost tree could possibly adversely affect the species. Tree removal associated with road construction, utility right-of-way maintenance, or recreational development may also result in alteration of roosting and/or feeding activities by the bats (i.e., the bats may have to fly farther to forage, seek alternate roosts, or they may be forced to abandon the area altogether). In addition, growing-season prescribed fires may result in burning of occupied roost trees. Smoke generated during prescribed burns could also cause roosting bats discomfort or death. Burning may cause a maternity colony or individual roosting bat to abandon a traditionally used roost tree.

Monitoring to determine take of individual bats within an expansive area of forested habitat is a complex and difficult task. Unless every individual tree that contains suitable roosting habitat is inspected by a knowledgeable biologist before management activities begin, it would be impossible to know if a maternity colony or roosting Indiana bats are present in an area proposed for harvest or other types of tree removal. It would also be impossible to evaluate the amount of incidental take of Indiana bats unless a post-harvest inspection is immediately made of every tree that has been removed or disturbed. Inspecting individual trees is not considered by the Service to be a practical survey method and is not recommended as a means to determine incidental take. However, the areal extent of potential roosting habitat affected can be used as a surrogate to monitor the level of take. Although, to the best of our knowledge, no Indiana bat maternity colony or individually roosting Indiana bats to date have been incidentally taken on the MTNF during tree removal or other habitat modifying activities, the possible removal of undiscovered occupied roost tree(s) may result in incidental take of this species. The Service believes if a maternity colony or roosting individuals are present in an area proposed for timber harvest or other disturbance, loss of suitable roosting habitat could result in incidental take of Indiana bats. However, implementation of the terms and conditions associated with the reasonable and prudent measures provided below by the Service, will significantly reduce the potential of incidental take.

This incidental take statement anticipates the taking of Indiana bats from activities (e.g., tree removal associated with timber harvest, road construction and maintenance, utility corridor maintenance, the development and maintenance of recreational areas, special uses; prescribed fires) conducted on the MTNF and associated with an annual removal of, or disturbance to, no more than 38,375 acres of potential Indiana bat habitat (Table 6).

The annual incidental take associated with the manipulation of 38,375 acres constitutes approximately 2.89% of the total forested area on the MTNF. Although the scarcity of records and lack of information on the distribution and movements of Indiana bats on the MTNF away from occupied hibernacula make it difficult to estimate the number of Indiana bats likely to be incidentally taken through the continued implementation of the LRMP on the National Forest, the Service would anticipate that no more than 5% of the total potential population of Indiana bats

(i.e., 500) on the MTNF would be adversely affected. Consequently, the Service anticipates that 25 Indiana bats or one maternity colony could be potentially taken during management activities that result in the accidental removal or disturbance of unknown, occupied roost trees. The potential for incidental taking of Indiana bats, however, is significantly reduced through the implementation of the terms and conditions associated with the reasonable and prudent measures provided below by the Service. Standards and guidelines outlined in the LRMP for the MTNF and the implementation of the terms and conditions associated with the reasonable and prudent measures provided below by the Service dictates that at least 7 potential roost trees per acre be provided in those areas subject to timber harvest or other types of tree removal activities. Consequently, the annual incidental take associated with the manipulation of 38,375 acres per year would provide a minimum of 268,625 potential roost trees for the estimated 500 Indiana bats that may occur on the MTNF during the spring-fall period, if we assume that the 500 Indiana bats could potentially occur throughout the National Forest, especially during spring and fall migration.

Table 6. Annual estimated management activities causing removal or disturbance of Indiana bat habitat on the Mark Twain National Forest, Missouri (from Eberly, in litt. March 8, 1999; Houf, pers. commun., April 19, 1999).

Activity	Number of Forested Acres Affected
Timber harvest	20,000
Prescribed fire	12,000
Wildlife habitat improvement	2,000
Timber stand improvement	4,000
Soil & water improvement	150
Range management	50
Mineral exploration and development	50
Wildfire fire lines	50
Special use	50
Road construction	25
Totals	38,375

Thus, a minimum of 537 potential roost trees per bat/ per year would be provided in those areas where habitat alterations occur. Within a 5-year period, the annual disturbance of 38,375 acres per year would yield a minimum of 1,343,125 potential roost trees available to the species.

Additionally, the potential impact to the species must be examined in the context of how many potential roost trees are likely to be available in the remaining acreage that is not disturbed each year. In a 5-year period, 38,375 x 5= 191,875 acres that would be disturbed. However, there are 1,065,426 acres of forest > 50 years of age that would produce trees that provide suitable roosting (i.e., trees 9-16" dbh) and foraging habitat for Indiana bats. Within the same time period, however, approximately 5,000 acres per year would grow into the > 50 year age class (5 x 5, 000= 25,000 acres). Adding 25,000 acres to our 1,065,426 acre baseline yields 1,090,426 acres. If we subtract the 191,875 acres that are disturbed within the same time frame, the difference is 898,551 acres. Multiplying 898,551 acres x the number of suitable roost trees per acre (~20) yields 17,971,020 roost trees available to the species. If we add the number of potential roost trees from disturbed areas within the 5-year period (i.e., 1,343,125) with the number of potential roost trees from undisturbed areas with the same 5-year period (i.e., 17,971,020), the total is 19,314,315. Dividing the total number of potential roost trees by the maximum number of Indiana bats that could use the MTNF (i.e., 500, and assuming that this number remains stable) suggests that a minimum of 38,628 potential roost trees would be available for each Indiana bat on the National Forest within a 5-year period, and an average of 7,726 trees per bat per year. Although several assumptions must be factored into such analysis, it does suggest that there will be an abundance of suitable roost trees for bats on the MTNF and that the impacts of the incidental take outlined above will be greatly minimized.

Operations on the MTNF that would exceed the annual level of incidental take in acreage of any one of the above-listed activities or in the number of bats would require reinitiation of formal consultation.

K. Effect of the take

The Service has determined that the level of anticipated take of Indiana bats is not likely to result in jeopardy to the species (see discussion above). Additionally, implementation of the reasonable and prudent measures (with implementing terms and conditions) presented below will further minimize the impact of incidental take to Indiana bats.

L. Reasonable and prudent measures

The Service believes the following reasonable and prudent measures are necessary and appropriate to further minimize impacts of incidental take of Indiana bats on the MTNF:

- ☞ Decrease possible adverse impacts to Indiana bats at known, occupied caves on the MTNF.

- ☞ Decrease possible adverse impacts to Indiana bats due to the removal of potentially occupied, suitable roost trees, especially near known occupied caves and areas where pregnant/lactating ♀♀ have been caught May 15- August 15, and on the Cedar Creek District which is located in an area of the state (i.e., north of the Missouri River) where the largest number of reproductively active females have been captured and which have the highest likelihood for the discovery of a maternity colony.

- ☞ Incorporating guidelines as outlined by Romme et al. (1995), increase the number of potential, suitable roost trees on the MTNF above what currently exists.

- ☞ Use appropriate smoke management techniques to minimize potential smoke impacts to occupied Indiana bat caves or roosting bats (both male roosts and maternity roosts).

- ☞ Monitor: 1) human disturbance and bat population numbers at White's Creek Cave, Cave Hollow Cave, and at any other occupied caves which may be found on lands managed by the MTNF in the future, 2) the status of Indiana bats on lands managed by the MTNF during the spring/fall period, and 3) the various levels of incidental take.

The Service believes that the reasonable and prudent measures outlined above will significantly reduce the impacts of incidental take of Indiana bats on the MTNF and that these measures are reasonable and fall within the Forest Service's responsibilities to conserve federally listed species as outlined in Sections 2(c)(1) and 7(a)(1) of the Act.

M. Terms and conditions

In order to be exempt from the prohibitions of section 9 of the Act, the Forest Service (MTNF) must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline the required reporting/monitoring requirements. These terms and conditions are non-discretionary.

In order to reduce possible adverse impacts to Indiana bats at known, occupied caves on the MTNF, the following is necessary:

- ☞ Continue protection of the two known, occupied Indiana bat caves on the MTNF by maintaining angle-iron gates; continue working with the Service and MDC to determine protection needs (e.g., gates, signs, etc.) of any additional occupied Indiana bat caves (hibernacula) discovered on the MTNF.

- ☞ Increase the area of old growth forest (old growth) around caves with current populations of Indiana bats to 20 contiguous acres and maintain a mature/overmature forest for an additional 130 acres around occupied caves with Indiana bat populations; this area will include the cave entrance, the area above any known cave passage, the foraging corridor from cave to nearest water source, and ridgetops/side slopes above the cave- a minimum of 150 acres of mature/overmature forest will be maintained around all occupied caves.

In order to decrease possible adverse impacts to Indiana bats due to the removal of potentially occupied roost trees, the following is necessary:

- ☞ For even-aged regeneration harvests, group "leave" trees around large snags, large live trees, and den trees to protect potential roost trees from wind throw.

- Within shelterwood harvests, retain a minimum of 25 basal area (BA) of residual trees; within clearcuts and seed tree harvests, retain a minimum of 15 BA of reserve trees; to the maximum extent possible, such reserve trees shall be located in groups and along intermittent drainages to provide foraging corridors into harvested areas.

- Determine an area of influence for each occupied Indiana bat cave that is on or adjacent to lands managed by the MTNF. The size and shape of this area of influence will be determined by: 1) significance provided to the cave as outlined by the Service (1983b, 1999) and as published in the *Federal Register* 32(48):4001 (i.e., Priority 1 or Priority 2, designated as critical habitat, etc.), 2) the maximum population number recorded, 3) the relative amounts of National Forest lands and other ownerships nearby, 4) current land use practices nearby, 5) the amount of preferred foraging habitat currently available (as defined by Romme et al. 1995), and 6) and additional conditions specific to that cave which may affect bat use. The area of influence shall not exceed a 5.0 mile radius circle centered on the hibernaculum following the findings of 3D/Environmental (1966), except as agreed to by the Service and Forest Service and determined to be based on best science available, result in the discovery of a larger foraging radius.

- In cooperation with the Service and MDC, develop a management recovery strategy within one year after issuance of this biological opinion for lands managed by the MTNF within the area of influence of any occupied Indiana bat cave located on the National Forest.

- In cooperation with the Service and MDC, develop a management recovery strategy within two years after issuance of this biological opinion for lands managed by the MTNF within the area of influence for all occupied Indiana bat caves adjacent to the MTNF.

- Management recovery strategies listed above for caves on and adjacent to, the MTNF, will include vegetation objectives for providing: a) a continuous supply of potential and suitable roost trees as outlined above, and b) ample preferred foraging habitat as outlined by Romme et al. (1995).

- In cooperation with the Service and MDC, develop a management recovery strategy within one year after issuance of this biological opinion, for lands managed by the MTNF within an area of influence approximately 3/4 of one mile [based on the foraging radius of a post-lactating female as determined by Gardner et al. (1991b)] centered on all locations where reproductively active females have been caught between May 15 and August 15. Such areas of influence shall be applicable to locations of reproductively active females recently (i.e., within the last five years) captured on lands adjacent to the MTNF as well as the locations of any reproductively active females discovered on the National Forest in the future. This management recovery strategy will include vegetation objectives for providing: a) a continuous supply of potential and suitable, maternity roost trees as

outlined above, and b) ample preferred foraging habitat as outlined by Romme et al. (1995).

- In the event that reproductively active female(s) is discovered on lands managed by the MTNF between May 15 and August 15, the following is requested: 1) in consultation with the Service, MDC, and other recognized bat experts, as needed, and when such actions will not knowingly result in the death or injury to the captured individual(s), conduct a radio telemetry study to determine the location of the maternity colony, 2) upon discovery of a maternity colony, immediately initiate informal consultation with the Service.

- If maternity colonies are discovered on the MTNF, roost trees used by such colonies are to be protected by establishing a zone centered on the maternity roost site. The actual area will be determined by a combination of topography, known roost tree locations, the proximity of permanent water and a site specific evaluation of the habitat characteristics associated with each colony. This area shall not exceed 3/4 of a mile radius circle centered on location of a maternity roost following the findings of Gardner et al. (1991b), except as agreed to by the Service and Forest Service and determined to be the best science available, result in the discovery of a larger foraging radius. Protective measures shall be established by developing a management recovery strategy, in cooperation with the Service and MDC, immediately upon discovery. Within this area:1) a minimum average of 24 potential roost trees per forested acre must be retained that may include snags, live shellbark and shagbark hickories ≥9"dbh, dead or dying trees with at least 10% exfoliating or defoliating bark ≥9" dbh, lightning struck trees ≥9" dbh, den or cull trees, and live trees ≥26" dbh, 2) the removal of occupied roost trees determined to be a safety hazard can only be done following consultation with the Service, 3) tree removal activities which would benefit the species may be performed only during a season when roosting bats are absent and only when it has been determined that roosts are unoccupied, 4) from 30% to 50% of mature oak-hickory and/or oak-pine forest with a canopy closure of 60-80%, following the guidelines outlined in Romme et al. (1995), must be maintained.

- For the Cedar Creek District, the following is requested: 1) to the maximum extent possible and logistically practical, maintain, on average, a minimum of 23 suitable roost trees per acre on forested acreage, 2) suitable roost trees contributing to the minimum listed above may include the following: 1) live shagbark and shellbark hickories ≥9" dbh, 2) lightning struck trees ≥9" dbh and trees ≥9" dbh, 3) dead or dying trees ≥9" dbh with at least 10% exfoliating or defoliating bark, 4) den or cull trees, and 5) live trees ≥26" dbh, 3) as outlined in the LRMP for the MTNF, incorporate only uneven-aged management techniques on this unit, 4) of the 23 roost trees maintained, to the maximum extent possible and logistically practical, retain all dead trees ≥20" dbh and all live trees ≥26" dbh unless they are an immediate human safety hazard, and 5) a canopy closure of 60-80% following the guidelines outlined in Romme et al. (1995) must be maintained.

In order to increase the number of potential, suitable roost trees on the MTNF above what

currently exists, the following is recommended:

- ☞ To the maximum extent possible and logistically practical, maintain, on average, a minimum of 23 suitable roost trees per acre on forested acreage on the MTNF. Suitable roost trees contributing to the minimum listed above may include the following: 1) live shagbark and shellbark hickories ≥9" dbh, 2) lightning struck trees ≥9" dbh and trees ≥9"dbh, 3) dead or dying trees ≥9" dbh with at least 10% exfoliating or defoliating bark, 4) den or cull trees, and 5) live trees ≥26" dbh.

- ☞ Of the 23 roost trees maintained, to the maximum extent possible and logistically practical, retain dead trees ≥20" dbh and live trees ≥26" dbh unless they are an immediate human safety hazard.

In order to minimize potential smoke impacts to occupied bat caves or roosting bats (both male bats and maternity roosts), the following is necessary:

- ☞ Consider occupied Indiana bat hibernacula as smoke sensitive areas during planning for prescribed burns conducted from November to April in the vicinity of occupied caves. Wind direction, speed, mixing height, and transport winds will be used during burn planning and implementation to minimize smoke drifting in or near occupied hibernacula.

- ☞ Consider areas near Indiana bat hibernacula ("areas of influence" as previously defined), the Cedar Creek District, and areas adjacent to locations where reproductively active females have been captured between May-July, as smoke sensitive areas during planning for prescribed fires conducted from May to October. Special precautions are to be taken to protect large snags (≥16" dbh) which are not safety hazards; such snags should be protected from fire and smoke. Wind direction, speed, mixing height and transport winds are to be used during burn planning and implementation to minimize smoke intensity and duration of burns.

- ☞ Prior to the employment of any prescribed fire, provide the Service's Columbia, Missouri Ecological Services Field Office with the opportunity to review burn plans that could potentially impact Indiana bats.

The MTNF will continue its efforts to determine habitat use of the National Forest by Indiana bats during the hibernation, summer roosting/maternity, and pre-hibernation seasons by directing the following monitoring activities. Selection of sites for future monitoring will be done in cooperation with the Service and MDC. Monitoring activities shall be directed through the Forest Service's North Central Experiment Station, appropriate university research institutions, MDC, the Biological Research Division of the U.S. Geological Survey, or private organizations/consultants. Monitoring activities must be conducted by individuals trained and experienced in working with Indiana bats following consultation with the Service and MDC. The Service believes that implementation of the following terms and conditions are necessary to

evaluate the underlying assumptions made on Indiana bat presence and characterized use on the MTNF. Implementation of these terms and conditions, in turn, will provide site-specific measures useful in evaluating the protective adequacy of the conservation measures outlined for the Indiana bat on the MTNF. In cooperation and consultation with the Service and MDC, the following monitoring activities should be investigated:

- Continued, regular monitoring of occupied Indiana bat caves on the MTNF to assess changes in population numbers, changes in microclimate, the effectiveness of protective structures currently in place, etc.

- Monitor the extent of use of Indiana bats on all districts of the MTNF. Such monitoring should include the employment of techniques to determine: 1) the presence or absence of the species on the National Forest, 2) habitat use and movements of Indiana bats during the spring-fall periods, 3) the location of any potential maternity sites, 4) the major foraging areas used by male Indiana near occupied caves during the summer and during spring-fall migration. Comparative analyses involving mist net surveys and Anabat Detectors are strong encouraged to assess the presence or absence of the species on the MTNF. The use of radio telemetry is strongly encouraged to determine the location of maternity colonies and is assessing habitat use and movements of the species throughout the National Forest.

- If monitoring activities result in the discovery of maternity sites on the MTNF, they will be protected along with associated roosts and foraging areas following the guidelines outlined above.

- Habitat use at all sites where Indiana bats are documented on the MTNF should be characterized and quantified at both local and landscape levels using GIS and other advanced computer software.

- The amount of incidental take (both total and categorical levels of forested acres affected and the number of bats) as identified in this opinion must be monitored on an annual basis. This information is to be provided to the Service's Columbia, Missouri Ecological Services Field Office, no later than 6 months following the end of the previous year's activities.

- The number of suitable roost trees and preferred foraging habitat available to the species shall on the MTNF shall be monitored according to the following schedule: 1) as part of the Forest Service's Forest Inventory Assessment (FIA), assess, at a minimum, once every ten years, the number of available, suitable roost trees and the amount of foraging habitat throughout the MTNF, and 2) annually monitor the number of available, suitable roost trees and the amount of foraging habitat within each of the following sampling areas: a) within 5 miles of all currently known or potentially discovered new occupied Indiana bat caves on the MTNF, b) within 3/4 miles of any location on the MTNF where a maternity

colony or reproductively active female is discovered, c) at selected sites sampled on the Cedar Creek District, and d) at selected sites sampled within all other districts of the MTNF. The degree of sampling and the selection of sampling sites will be determined in consultation with the Service and MDC and identified by October 1, 1999.

- ☞ The results of all monitoring activities shall be provided to the Service's Columbia, Missouri Ecological Services Field Office, and MDC, no later than December 31 of each year.

- ☞ Provide to personnel of the Service's Columbia, Missouri Ecological Services Field Office and to MDC, an opportunity to conduct site visits to all districts of the MTNF, to evaluate compliance of monitoring requirements. Site visits will be scheduled by mutual consent of the Service and personnel of the MTNF. Upon completion of such visits, the Service will provide a written report on the results of such field investigations.

When applicable, monitoring the incidental take of Indiana bats should done by adhering to the following guidelines:

- ☞ Care must be taken in handling dead bat specimens that are found on the MTNF to preserve biological material in the best possible state.

- ☞ Any dead specimens found should be placed in plastic bag and refrigerated as soon as possible following discovery.

- ☞ The finding of any dead specimen should be reported immediately following discovery to: 1) Larry Keck, Senior Resident Agent, U.S. Fish and Wildlife Service, 1103 A Southwest Blvd., Jefferson City, MO 65109, 573-636-7815, 2) Bruce Maldonado, U.S. Forest Service, Mark Twain National Forest, 401 Fairgrounds Rd., Rolla, MO 65401, 573-341-7463, and 3) R. Mark Wilson, Field Supervisor, U.S. Fish and Wildlife Service, 608 E. Cherry St., Room 200, Columbia, MO 65201-7712.

N. Conservation recommendations

Sections 2(c)(1) and 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purpose of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The Service recommends that the MTNF implement the following conservation measures for the benefit of the Indiana bat:

- ☞ In consultation with the Service and MDC, direct a study [similar to currently ongoing MOFEP (Missouri Ozark Forest Ecosystem Project)] to determine the potential impact of

various timber management activities (including different types of even-aged and uneven-aged management)on potential Indiana bat habitat; such a study should involve pre-treatment and post-treatment surveys of Indiana bats to analyze the potential response of the species to different forestry and wildlife prescriptions.

- ☞ By December 31 of a year that such a study is completed, provide a copy of the results to Service's Columbia, Missouri Ecological Services Field Office, and to MDC.

- ☞ In consultation with the Service and MDC, develop an educational slide program on the status of the Indiana bat in the eastern United States, Missouri, and on the MTNF; various aspects of its life history and habitat requirements; reasons why human disturbance of maternity colonies or hibernacula can adversely impact the species; steps that can be taken to decrease the impact of incidental take of the species; the ecological benefits of bats, etc.

- ☞ In consultation with the Service and MDC, continue to conduct training for employees of the MTNF on bats (including Indiana bat) occurring on the National Forest; training should include sections on bat identification, biology, habitat requirements, and sampling techniques (including instructions on applicability and effectiveness of using mist net surveys vs. Anabat detectors to accurately determine the presence of various bat species); the proper training of MTNF biologists on bat identification and a reliable methods for counting roosting bats will enable the Forest Service to continue to monitor the status of this species independently of other agencies and research institutions.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

The Service believes that implementation of the terms and conditions associated with the reasonable and prudent measures listed above and implementation of the conservation recommendations as outlined above for the Indiana bat, will significantly contribute to the Forest Service's responsibility under Section 7 (a) (1) to consult with Service in the development of a conservation program that will advance the recovery of this species.

Mead's milkweed

A. Species/habitat description/life history

Asclepias meadii is an obligate outcrossing, long-lived, late-successional perennial that is restricted primarily to virgin tall grass prairies, prairie haymeadows, and glades (Tecic *et al.* 1998). It has also occasionally been reported from prairie remnants, sandstone barrens, and sandstone ledges (Voight and Mohlenbrock 1964; Chaplin *et al.* 1994; Tecic *et al.* 1998) It usually begins its seasonal growth in mid to late April. It has a solitary, slender, unbranched stalk, 20-40 centimeters (8-16 inches) high that is glabrous but covered with a whitish, waxy covering. Leaves are opposite, broadly ovate, 5-7.5 centimeters (2-3 inches) long, 1-5 centimeters

(3/8-2 inches) broad, glabrous, and also covered with a whitish, waxy covering. A solitary umbel at the summit of a long stalk consisting of 6-15 greenish ivory/cream colored flowers is produced in late May and early June. When sexual reproduction is successful, young green fruit pods are formed by late June and reach their maximum length of 4-8 centimeters (1.5-3 inches) by late August or early September. Mature seeds are produced by mid-October (Morgan 1980; Kurz and Bowles 1981). This species is pollinated by small bumblebees (*Bombus*) and miner bees (*Anthorphora*), the pollen is dispensed in pollinia, and its seeds are wind-dispersed from follicles (Betz and Lamp 1992; Betz *et al.* 1994; Tecic *et al.* 1998). Mead's milkweed requires from three to eight years to reach reproductive maturity from seed under cultivated conditions (Betz and Hohn 1978; Betz 1989).

B. Status and distribution

Mead's milkweed (*Asclepias meadii*) was officially listed as a threatened species on September 1, 1988 (53 *Federal Register*: 33992-33995). *Asclepias meadii* is state listed as endangered in Missouri and is ranked S2 (state imperiled), G2 (globally imperiled) (Missouri Department of Conservation 1998). The species formerly occurred primarily in native tall grass prairies in Illinois, Indiana, Iowa, Kansas, Missouri, and Wisconsin but is now considered extirpated in Indiana and Wisconsin (Bowles *et al.* 1998; Tecic *et al.* 1998) and is threatened with extirpation in Iowa (Watson 1998). Although approximately 150 extant populations (Bowles *et al.* 1998) of this species are scattered across 31 counties in Illinois, Iowa, Missouri, and Kansas (Tecic *et al.* 1998), the majority are now restricted to primarily "high quality" tall grass prairies and prairie haymeadows in Kansas and Missouri, and on igneous glades in Iron and Reynolds counties, Missouri (Chaplin *et al.* 1994; Bowles *et al.* 1998; Tecic *et al.* 1998).

In Iowa, the species is believed to be extant at seven sites in six counties, but there the species only occurs on small, isolated prairie remnants that contain low to very low numbers of individual plants (Watson 1998). In 1998, Watson (1998) surveyed six of the seven extant sites in Iowa and located the species at only one site (Woodside Prairie). Although he found seven flowering plants that produced two mature pods, he concluded that *"Asclepias meadii* must at present be considered near the brink of extinction in Iowa" (Watson 1998). Of the currently known two populations in Illinois, one is represented by a single plant from a remnant railroad prairie in Ford County, and the other consists of four colonies scattered on four small glades in the Shawnee Hills, Saline County (Tecic *et al.* 1998).

Total reproductive success in Mead's milkweed is low (Betz 1989; Thurman and Hickey 1989; Bowles *et al.* 1998; Tecic *et al.* 1998) and the species has been essentially extirpated from many of the locations in the eastern portion of its range where it consists of genetic clones that may be incapable of reproduction and long-term population maintenance (Schall *et al.* 1993; Bowles *et al.* 1998; Tecic *et al.* 1998). Successful fruit production has been estimated to be as low as 15 percent (Kurz and Bowles 1981) and the species does not flower every year (Thurman and Hickey 1989). Additionally, many populations throughout the range of the species are small and contain only a small number of plants (Watson 1992; Bowles *et al.* 1998; Tecic *et al.* 1998; Watson 1998). Watson (1992) postulated that the species may remain dormant some years due to several

unknown environmental factors. This theory is supported by the observations of Betz and Hohn (1978) who noted that populations of this species fluctuate widely from year to year, and individual plants known to flower for several successive years may subsequently disappear completely for a few years.

Schaal *et al.* (1993), Bowles *et al.* (1998), and Tecic *et al.* (1998) have also reported a reduction in genetic diversity in prairies that are managed as hay meadows compared to those managed with prescribed fire. Currently, only two populations of Mead's milkweed reproduce sexually and produce viable seed on a regular basis: Rockefeller Prairie in Jefferson County, Kansas, and the Weimer Hill igneous glade in Iron County, Missouri (Bowles *et al.* 1998; Tecic *et al.* 1998), both of which have been managed primarily by using prescribed fire. Tecic *et al.* (1998) used allozyme electrophoresis to compare the genetic variability of plants at these two sites with plants from other populations on hay meadows and determined that the two fire-managed populations had more genotypes and fewer ramets per genet than those on hay meadows. They further postulated that the "inhibition of sexual reproduction may have resulted in clonal spread and attrition of genotypes, thus exacerbating the effects of sexual incompatibility and inbreeding.

Main reasons listed for this species' decline include the destruction and modification of native tall grass prairie for agricultural development, urban expansion; over grazing and hay mowing which are detrimental to the plant's reproductive cycle; insect predation; erosion; fire suppression; encroachment of woody vegetation; application of herbicides; and foot trampling (Harrison 1988; Chaplin 1994; Bowles *et al.* 1998; Tecic *et al.* 1998). Although the species can survive vegetatively for decades under a management strategy of solely haymowing, Bowles *et al.* (1998) suggested that eventual sexual reproduction and recombination was necessary for long term survival. Haymowing is a cultural management practice that has existed in some areas for almost a century (Fitch & Hall 1978). This practice removes developing seed pods and prevents sexual reproduction (McGregor 1977; Betz 1989; Bowles *et al.* 1998; Tecic *et al.* 1998). Bowles *et al.* (1994) noted that "in such populations, recruitment is by asexual reproduction, and genetic diversity can be lost through attrition of genotypes."

The few populations on igneous glades in Iron and Reynolds counties, Missouri, that reproduce sexually are apparently threatened with continued fragmentation due to forest encroachment resulting from fire suppression (Guyette & McGinnes 198; Guyette & Cutter 1991; Ladd 1991; Tecic *et al.* 1998). Due to the continued destruction of native prairie, the persistent haymowing on others, and fire suppression in some areas, this species is apparently continuing to decline. The decrease in genetic diversity on some prairies due to continued hay cutting activities further threatens the long term survival of this species (Schaal *et al.* 1993; Bowles *et al.* 1998; Tecic *et al.* 1998). Nonetheless, recent propagation and restoration experiments in northeastern Illinois and northwestern Indiana have been partially successful and provide hope that the species can still be recovered (Bowles *et al.* 1994; Bowles *et al.* 1998). Currently, Mead's milkweed is known from 56 extant occurrences scattered within the following 12 Missouri counties: Barton, Benton, Cass, Cedar, Dade, Harrison, Iron, Pettis, Polk, Reynolds, St. Clair, and Vernon.

C. Status of the species within the action area

The only known location of *Asclepias meadii* on the Mark Twain National Forest is on an igneous glade within the Bell Mountain Wilderness in Iron County. In 1993, Craig Anderson of the Missouri Department of Conservation discovered a small population of eight plants on a small opening of glade that was part of complex of glades within the wilderness (Missouri Department of Conservation1997). Seven of the eight plants had inflorescences and were in healthy condition. Although this one population only constitutes approximately 0.67% of the known extant sites in the United States and only about 2 % of the sites in Missouri, it represents an estimated 8% of those populations in the country that reproduce sexually, and is therefore important to the recovery of the species.

D. Effects of the action (direct and indirect effects)

All factors affecting the species' environment within the action area are associated with the designated wilderness status of that portion of Bell Mountain managed by the Forest Service. Outside its designation as a wilderness, other activities identified in the environmental baseline are not applicable for this species because of the restrictions that accompany such a designation. However, the wilderness designation does provide some beneficial effects to the species. For example, under the wilderness designation, timber management, motorized vehicles, developed facilities, herbicide application, mineral exploration, and unless authorized by law, pipelines and transmission lines are all prohibited from such areas (U.S. Forest Service 1986). The restrictions listed above would benefit Mead's milkweed by greatly reducing disturbance to existing populations.

Direct effects

While many operations are restricted within the designated wilderness, other activities could directly or indirectly impact the species. Mead's milkweed could be directly impacted from foot and horse traffic, ground disturbance associated with primitive camping, and non-prescribed fires that are accidentally or deliberately set during the growing season.

Indirect effects

The greatest potential threat to the species within the action area would be the continued suppression of prescribed fires. Research by Bowles *et al.* (1998) and Tecic *et al.* (1998) have provided strong evidence that prescribed fires are essential to successful sexual reproduction and the long term survival of the species. Several igneous glades adjacent to or in the vicinity of this wilderness are inhabited by several populations of Mead's milkweed on public property owned by the MDC or MDNR (Missouri Department of Conservation 1997; e.g., Profit Mountain, Wildcat Mountain, Ketcherside Mountain Conservation Area, Weemer Hill). Recent studies by the MNDR involving prescribed fires in some of these areas have supported the findings of Bowles *et al.* (1998) and Tecic *et al.* (1998) that *Asclepias meadii* responds well following burning, but soon disappears if fires are not utilized on a regular basis (pers. commun., Ken McCarty, Missouri Department of Natural Resources, February 1999). Without the use of prescribed fires within the action area, it is extremely probable that Mead's milkweed will also disappear from the Bell Mountain Wilderness. Prescribed fires, however, can only be allowed if approved by the Chief

of the Forest Service. Nonetheless, such approval is possible, if it can be shown that "fire is essential to aid, maintain, or restore natural plant communities or threatened or endangered plant species." (U.S. Forest Service 1998).

E. Cumulative effects

Cumulative effects include the effects of future State, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA. The Service is not aware of any future State, local, or private actions that are reasonably certain to occur within the action area that would qualify as cumulative effects.

F. Conclusion

After reviewing the current status of Mead's milkweed; the environmental baseline for the action area; the effects of forest management and other activities on the MTNF (both direct and indirect); additional measures identified in the Forest Service's BA to assist in the protection, management, and recovery of the species; and any potential cumulative effects, it is the Service's biological opinion that forest management and other activities authorized, funded, or carried out by the MTNF, are not likely to jeopardize the continued existence of Mead's milkweed. Because critical habitat has not been designated for this species, none will be adversely affected by the continued implementation of the LRMP.

G. Conservation recommendations

Sections 2(c)(1) and 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purpose of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

We believe that this provision of the ESA places an obligation on all Federal agencies to implement positive programs to benefit listed species, and a number of recent court cases appear to support that belief. Agencies have some discretion in choosing conservation programs, but Sections 2 (c) (1) and 7(a)(1) place a mandate on agencies to implement some type of programs.

The Service, therefore, recommends that the MTNF implement the following conservation measures to benefit Mead's milkweed:

- ☞ Seek approval from the Chief of the Forest Service to regularly conduct prescribed fires on the portion of the Bell Mountain Wilderness which provides habitat for Mead's Milkweed.

- ☞ Develop a management strategy for the Bell Mountain Wilderness to perpetuate an open glade ecosystem there. Such a strategy would include, but not be limited to, the use of prescribed fire and other accepted management techniques (e.g., manual removal of

woody vegetation, etc.).

- ☞ Because populations of this species can fluctuate widely year to year due to several environmental parameters, annual surveys should be conducted on the wilderness, in consultation with the Service and MDC, especially to determine this species' response to prescribed fires. Following adequate burning, it is possible that additional populations of Mead's milkweed could be discovered on new areas of the wilderness where the species has never been recorded.

- ☞ Primitive camping, horseback riding, and excessive foot traffic should be prohibited from those areas of Bell Mountain Wilderness that inhabit the species. Hiking and horsebacking riding trails should be routed away from all existing Mead's milkweed populations.

- ☞ Demographic life history studies should be conducted on the population to determine the degree of sexual reproduction; the percent of flower, pod, and viable seed production, seedling establishment; and the longevity of plants through time. Such studies could be done in cooperation and conjunction with a larger project involving the Missouri Department of Conservation, the Missouri Department of Natural Resources, the Fish and Wildlife Service, and the Morton Arboretum. Such a partnership could maximize funding possibilities and allow for strong collaboration among the agencies involved to ensure that prescribed fires, surveys, and life history work are well coordinated.

- ☞ An annual report on the outcome of all research activities conducted within the Bell Mountain Wilderness should be submitted to the Service by December 31 of each year.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

III. REINITIATION NOTICE

This concludes formal consultation on the Forest Service's reinitiation request of September 8, 1998, on the effects of the continued implementation of the LRMP on the MTNF to the gray bat, bald eagle, Indiana bat, and Mead's milkweed. As provided in 50 CFR § 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: 1) the amount or extent of incidental take is exceeded; 2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; 3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or 4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

IV. APPLICABILITY OF BIOLOGICAL OPINION TO SITE SPECIFIC PROJECTS

The Service believes that scope of effects for specific projects developed through the continued implementation of the LRMP on the MTNF falls under the umbrella of this consultation for the following reasons:

- The terms and conditions associated with the reasonable and prudent measures outlined in this opinion will minimize the impact of the incidental take identified for the gray bat, bald eagle, and Indiana bat on both a programmatic and site specific level; the protective measures outlined herein for the entire MTNF are applicable to individual projects yet to be identified.

- If after adhering to the terms and conditions associated with the reasonable and prudent measures provided in this opinion, the Forest Service determines that activities on a project level are likely to adversely affect the gray bat, bald eagle, or Indiana bat, the Service would request that formal consultation be initiated.

- Any individual project that results in the level of incidental take identified in this opinion to be exceeded would necessitate the reinitiation of formal consultation as outlined above.

- The Forest Service will continue to conduct site-specific project analyses to ensure that each individual action follows recommendations set forth in this opinion.

- The Service will continue to review all site-specific projects to ensure that there is strict adherence to the terms and conditions associated with the reasonable and prudent measures outlined in this opinion and that incidental take levels identified in this opinion are not exceeded.

V. LITERATURE CITED

Andrew, J.M. and J.A. Mosher. 1982. Bald eagle nest site selection and nesting habitat in Maryland. *J. Wildl. Manage*. 46(2):382-390.

Anonymous. 1987. Vandals destroy hibernating Indiana bats. Bats (quarterly newsletter of Bat Conserv. Internat., Austin, TX) 5(2):5-8.

Barbour, R.W. and W.H. Davis. 1969. Bats of America. Univ. Press of Kentucky, Lexington. 286 pp.

Barrett, S.W. 1980. Indians and fire. *Western Wildlands* 6:17-21.

Belwood, J. J. 1979. Feeding ecology of an Indiana bat community with emphasis on the endangered Indiana bat, *Myotis sodalis*. M.S. Thesis, Univ. Florida, Gainesville, FL 103pp.

Betz, R.F. 1989. Ecology of Mead's milkweed (*Asclepias meadii* Torrey). Pages 187-191 *in* T.B. Bragg & J. Stubbendieck, eds.: Proceedings of the Eleventh North American Prairie Conference, University of Nebraska at Lincoln.

Betz, R.F., and J.E.Hohn. 1978. Status Report for *Asclepias meadii*. Unpubl. Report-Nortwestern Illinois University, Evanston, Illinois. 9pp.

Betz, R.F., and H.F. Lamp. 1978. Flower, pod, and seed production in eighteen species of milkweeds (*Asclepias*). Pages 25-30 *in* D.D. Smith & C.A. Jacobs, eds.: Recapturing a Vanishing Heritage: Proceedings of the Twelfth North American Prairie Conference, University of Northern Iowa, Cedar Falls.

Betz, R., D. Struven, J.E. Wall & F.B. Heitler. 1994. Insect pollinators of 12 milkweed (*Asclepias*) species. Pages 45-60 *in* R.G. Wickett, P.D. Lewis, A. Woodliffe, & P. Pratt (eds.): Proceedings of the Thirteenth North American Prairie Conference, Department Of Parks & Recreation, Winsor, Ontario.

BHE Environmental, Inc. 1999. 1998 Annual report: implementation of reasonable and prudent measures & terms and conditions in the biological opinion for BRAC implementation at Fort Lenoard Wood. Unpubl. Rep.- 3DE Group of BHE Environmental, Inc., Cincinnati, Ohio. 199pp. + appendices.

Bowles, J.B. 1981. Ecological studies on the Indiana Bat in Iowa. Central College, Pella, Iowa. 28 pp.

Bowles, J. B. 1982. Results of monitoring of Indiana bat maternity sites in south-central Iowa. Unpubl. report to Iowa Conserv. Commission.

Bowles, M.L., J.L. McBride, and R.F. Betz. 1998. Management and restoration ecology of the Federal threatened Mead's milkweed (*Asclepias meadii*) (ASCLEPIADACEAE). *Ann. Missouri Bot. Gard.* 85:110-125.

Brack, V. 1979. Determination of presence and habitat suitability for the Indiana bat (*Myotis sodalis*) and gray bat (*Myotis grisescens*) for portions of three ditches, Big Five Levee and Drainage District, Union and Alexander Counties, Illinois. U.S. Army Corps of Engineers, St. Louis, MO 23pp.

Brack, V., Jr. 1983. The nonhiberating ecology of bats in Indiana with emphasis on the endangered Indiana bat, *Myotis sodalis*. Ph.D. dissertation, Purdue University, Lafayette, Ind. 280pp.

Brack, V., and R. K. LaVal. 1985. Food habits of the Indiana bat in Missouri. *J. Mamm.* 66:308-315.

Brack, V., Jr., K. Tyrell, and K. Dunlap. 1991. A 1990-1991 winter cave census for the Indiana bat (*Myotis sodalis*) in non-priority 1 hibernacula in Indiana. Ind. Fed. Aid Proj. E-1-6, Study No. 18, Ind. Dept. Nat. Resour., Indianapolis. 45pp.

Buehler, D.A., T.J. Mersmann, J.D. Fraser, and J.K.D. Seegar. 1991. Effects of human activity on bald eagle distribution on the northern Chesapeake Bay. J. Wildl. Manage. 55:282-290.

Callahan, E.V., III. 1993. Indiana bat summer habitat requirements. M.S. thesis, University of Missouri, Columbia, 74 pp.

Callahan, E. V., R. D. Drobney, and R. L. Clawson. 1997. Selection of summer roosting sites by Indiana bats (*Myotis sodalis*) in Missouri. *J. Mamm.* 78:818-825.

Chaplin, C., R. Betz, C. Freeman, D. Roosa, T. Toney, & M. Bowles (ed.). 1994. Draft recovery plan for Mead's milkweed (*Asclepias meadii* Torr.). U.S. Fish and Wildlife Service, Chicago, Illinois.

Clark, D.R., Jr. 1981. Bats and environmental contaminants: a review. USDI Fish and Wildlife Service Special Scientific Report. Wildlife No. 235, 27 pp.

Clark, D.R., Jr., R.K. LaVal, and D.M. Swineford. 1978. Dieldrin-induced motality in an endangered species, the gray bat (*Myotis grisescens*). *Science* 199: 1357-1359.

Clark, D. R., Jr., and R. M. Prouty. 1976. Organochlorine residues in three bat species from four localities in Maryland and West Virginia, 1973. *J. Pestic. Monitor.* 10:44-53.

Clark, B.L., J.B. Bowles, and B.S. Clark. 1987. Summer habitat of the endangered Indiana bat in Iowa. *Amer. Midl. Nat.* 118:32-39.

Clawson, R. 1984. A determination of the source and effects of pesticide poisoning of gray bats in Boone County, Missouri. Final Report Federal Aid Project No. W-13-R-38, Study No. 71. Missouri Department of Conservation, Jefferson City, Missouri. 15pp.

Clawson, R. 1986. An investigation of the summer distribution and status of Indiana bats in Missouri. Final Report- Fed. Aid Proj. W-13-R, Fish and Wildl. Research Cent., Columbia, Missouri. 17pp.

Clawson, R. 1987. Indiana bats: down for the count. *Endangered Species Technical Bull.* 22(9):9-11.

Clawson, R.L., R.K. LaVal, M.L. LaVal and W. Caire. 1980. Clustering behavior of hibernating *Myotis sodalis* in Missouri. J. of Mammal. 61:245-253.

Clawson, R.L., R. Titus, D. Figg, L. Burger, C. Hauser, T. French, and D. Beffa. 1992. Management plan for the Indiana bat and the gray bat in Missouri. Unpubl. Report, Missouri Department of Conservation, Jefferson City, 39pp.

Cope, J. B., A. R. Richter and R. S. Mills. 1974. Concentrations of the Indiana bat, *Myotis sodalis*, in Wayne County, Indiana. Proc. *Indiana Acad. Sci.* 83:482-484.

Cope, J. B. and S. R. Humphrey. 1977. Spring and autumn swarming behavior in the Indiana bat, *Myotis sodalis*. J. Mamm. 58:93-95.

Cope, J. B., A. R. Richter, and D. A. Searly. 1978. A survey of bats in Big Blue Lake project area in Indiana. U. S. Army Corps of Engineers, 51pp.

Daan, S. 1973. Activity during natural hibernation in three species of vespertilionid bats. *Netherlands J. Zool.* 23:1-77.

Dalton, V.M. 1987. Distribution, abundance, and status of bats hibernating in caves in Virginia. *Virginia J. of Sci.* 38(4):369-379.

DeBlase, A. F., S. R. Humphrey, and K. S. Drury. 1965. Cave flooding and mortality in bats in Wind Cave, Kentucky. *J. Mamm.*, 46:96.

Easterla, D.A., and L.C. Watkins. 1969. Pregnant *Myotis sodalis* in northwestern Missouri. *J. Mamm.* 50:372-373.

Edwards, C.C. 1969. Winter behavior and population dynamics of American eagles in Western Utah. Ph.D. Thesis. Bringham Young University, Provo, Utah. 142pp.

Elder, W.H, and W.J. Gunier. 1981. Dynamics of a gray bat population (*Myotis grisescens*) in Missouri. *Amer. Midl. Nat.* 105(1):193-195.

Fenneman, N.M. 1938. Physiography of eastern United States. McGraw-Hill Book Co., New York. 662pp.

Fitch, H.S. & W.D. Kettle. 1978. A 20-year record of succession on reseeded field of tall grass prairie on the Rockefeller experimental tract. Special publ. No. 4, Museum of Natural History, The University of Kansas, Lawrence.

Gardner, J.E., and T.L. Gardner. 1990. Determination of presence and habitat suitability for the Indiana bat (*Myotis sodalis*) and gray bat (*M. grisescens*) for portions of the lower 6.6 miles of McGee Creek. Unpubl. Report prepared for the U.S. Army Corps of Engineers, McGee District Drainage and Levee District, St. Louis District, Corps of Engineers.

Gardner, J.E., J.D. Garner, and J.E. Hofmann. 1990. Combined progress reports: 1989 and 1990 investigations of *Myotis sodalis* (Indiana bat) distribution, habitat use, and status in Illinois. Progress report for the U.S. Dept. of Interior, Fish and Wildlife Service, Twin Cities, Minnesota, 19 pp.

Gardner, J.E., J.D. Garner and J.E. Hofmann. 1991a. Summer roost selection and roosting behavior of *Myotis sodalis* (Indiana bat) in Illinois. Final report. Illinois Natural History Survey, Illinois Department of Conservation. Champlain, Illinois. 56 pp.

Gardner, J.E., J.D. Garner and J.E. Hofmann. 1991b. Summary of *Myotis sodalis* summer habitat studies in Illinois: with recommendations for impact assessment. Special report. Illinois Natural History Survey, Illinois Department of Conservation. Champaign, Illinois. 28 pp.

Garner, J.D. and J.E. Gardner. 1992. Determination of summer distribution and habitat utilization of the Indiana bat (*Myotis sodalis*) in Illinois. Unpubl. Report. Endangered Species Coordinator, Region 3, USFWS, Twin Cities, MN 28 pp.

Geluso, K. N., J. S. Altenbach, and D. E. Wilson. 1976. Bat mortality: pesticide poisoning and migratory stress. *Science* 194:184-186.

Gerrard, J.M., and G.R. Bortolotti. 1988. The bald eagle: haunts and habits of a wilderness monarch. Smithsonian Press, Washington, D.C. 177pp.

Giessman, N., T.W. Barney, T.L. Haithcoat, J.W. Meyers, and B. Massengale. 1986. Distribution of forestland in Missouri. *Trans. Missouri Acad. of Sci.* 20:5-14.

Grewe, A.A., Jr. 1966. Some aspects in the natural history of the bald eagle (*Haliaeetus leucocephalus*, in Minnesota and South Dakota. Ph.D. Thesis. University of South Dakota, Vermillion, South Dakota. 68pp.

Griffin, C.R., T.S. Baskett, and R.D. Sparrowe. 1982. Ecology of bald eagles wintering near a waterfowl concentration. U.S. Fish and Wildlife Service Special Sci. Rep.-Wildl. No. 247. Washington, D.C. 12pp.

Guyette, R., & E.A. McGinnes. 1982. Fire history of an Ozark Missouri glade in Missouri. *Trans. Missouri Acad. Sci.* 16:85-93.

Guyette, R.P., and B.E. Cutter. 1991. Tree ring analysis of a post oak savanna in the Missouri Ozarks. Natural Areas J. 11:93-99.

Hall, E.R. 1981. The Mammals of North America. Vol. I. John Wiley and Sons, New York. 690 pp.

Hall, J. S. 1962. A life history and taxonomic study of the Indiana bat, *Myotis sodalis*. Reading Publ. Mus. Art., Gallery Publ. 12:1-68.

Hansen, M.H., T. Fireswyk, J.F. Glover, and J.F. Kelly. 1992. The eastwide forest inventory database: users manual. USDA, Forest Service- North Central Forest Experiment Station Gen. Tech. Rep. NC-151. St. Paul, Minnesota. 48pp.

Harrison, W.F. 1988. Endangered and threatened wildlife and plants: determination of threatened status for *Asclepias meadii* (Mead's milkweed). U.S. Fish and Wildlife Service, Department of the Interior. *Federal Register* 53(170):33992-33995.

Hassell, M.D. and M.J. Harvey. 1965. Differential homing in *Myotis sodalis*. *Am. Midl. Nat.* 74:501-503.

Hobson, C.R. 1993. Status, distribution, and summer ecology of bats in western Virginia: A survey for the endangered Indiana bat, *Myotis sodalis*. 1993. Report to Virginia Department of Game and Inland Fisheries Non-game Division, Richmond, VA. 18 pp.

Hobson, C.R. and J.N. Holland. 1995. Post-hibernation and foraging habitat of a male Indiana bat, *Myotis sodalis* (Chiroptera: Vespertillionidae), in western Virginia. *Brimleyana* 23:95-101.

Hopkins, D.S. 1988. Winter populations, foraging activity, and night roost observations of bald eagles on the Mississippi River near Burlington, Iowa. M.S. Thesis, Western Illinois University. 73pp.

Humphrey, S. R. 1978. Status, winter habitat, and management of the endangered Indiana bat, *Myotis sodalis*. *Florida Scientist* 41:65-76.

Humphrey, S.R. and J.B. Cope. 1977. Survival rates of the endangered Indiana bat, *Myotis sodalis*. *J. Mammal.* 58:32-36.

Humphrey, S.R., A.R. Richter and J.B. Cope. 1977. Summer habitat and ecology of the endangered Indiana bat, *Myotis sodalis*. *J. of Mammal.* 58:334-346.

Jacobson, R.B., and A.T. Primm. 1997. Historical land-use changes and potential effects on stream disturbance in the Ozark Plateaus, Missouri. U.S. Geological Survey Water-Supply Paper 2484, Denver, Colorado. 85pp.

Johnson, S.A., V. Brack, Jr.,and R.E. Rolley. 1998. Overwinter weight loss of Indiana bats (*Myotis sodalis*) from hibernacula subject to human visitation. Am. Midl. Nat. 139:255-261.

Jonen, J.R. 1973. The winter ecology of the bald eagle in west-central Illinois. M.S. Thesis.

Western Illinois University, Macomb, Illinois. 84pp.

Kennedy, J., and S. Ducummon. 1999. 1999 Winter bat survey in Pilot Knob Mine, Iron County, Missouri. Unpubl. Rep. to the U.S. Fish and Wildlife Service, Columbia, Missouri. 12pp.

Kiser, J. D. and C. L. Elliott. 1996. Foraging habitat, food habits, and roost tree characteristics of the Indiana bat (*Myotis sodalis*) during autumn in Johnson County, Kentucky. Final report, Kentucky Dept. of Fish and Wildl. Resources, Frankfort, Kentucky. 65 pp.

Kiser, J., C. Elliott, and J. MacGregor. 1996. The use of roost trees by Indiana bats, *Myotis sodalis*, during autumn. Presented at the sixth colloquium on the Conservation of Mammals in the Southern and Central United States.

Kurta, A. 1980. Status of the Indiana bat, *Myotis sodalis*, in Michigan. *Mich. Acad.* 13:31-36.

Kurta, A., and J.A. Teramino. 1994. A novel hibernaculum and noteworthy records of the Indiana bat and eastern pipistrelle (Chiroptera: Vespertilionidae). *Am. Midl. Nat.* 132:410-413.

Kurta, A., and J. O. Whitaker, Jr. 1998. Diet of the endangered Indiana bat (*Myotis sodalis*) on the northern edge of its range. *Am. Midl. Nat.* 140:280-286.

Kurta, A.J., J. Kath, E.L. Smith, R. Foster, M.W. Orick, and R. Ross. 1993. A maternity roost of the endangered Indiana bat (*Myotis sodalis*) on the northern edge of its range. *Am. Midl. Nat.* 129:132-138.

Kurta, A., D. King, J.A. Teramino, J.M. Stribley, and K.J. Williams. 1993. Summer roosts of the endangered Indiana bat (*Myotis sodalis*) on the northern edge of its range. *Am. Midl. Nat.* 129:132-138.

Kurta, A., K.J. Williams, and R. Mies. 1996. Ecological, behavioral, and thermal observations of a peripheral population of Indiana bats (*Myotis sodalis*). Pages 102-117 *in* Bats and Forests Symposium (R.M.R. Barclay and R.M. Brigham, eds.). Research Branch, British Columbia Ministry of Forests, Victoria, British Columbia, Canada, Working Paper 23:1-292.

Ladd, D. 1991. Reexamination of the role of fire in Missouri oak woodlands. Pages 67-80 in G.V. Burger, J.E. Ebinger, & G.S. Wilhelm, eds.: Proceedings of the Oak Woods Management Workshop, Eastern Illinois University, Charleston, Illinois.

LaVal, R.K., R.L. Clawson, M.L. LaVal and W. Caire. 1977. Foraging behavior and nocturnal activity patterns of Missouri bats, with emphasis on the endangered species *Myotis grisescens* and *Myotis sodalis*. *J. Mamm.* 58:592-599.

LaVal, R. K., R. L. Clawson, W. Caire, L. R. Wingate, and M. L. LaVal. 1976. An evaluation of

the status of Myotine bats in the proposed Meramec Park Lake and Union Lake project areas, Missouri. Special Report. U.S. Army Corps of Engineers, St. Louis, MO 136pp.

LaVal, R.K. and M.L. LaVal. 1980. Ecological studies and management of Missouri bats, with emphasis on cave-dwelling species. Missouri Dept. Conserv. Terrestrial Series 8:1-53.

Lee, Y.-F. 1993. Feeding ecology of the Indiana bat, *Myotis sodalis*, and resource partitioning with *Myotis keenii* and *Myotis lucifugus*. Unpubl. M. S. thesis, The Univ. of Tennessee, Knoxville, Tennessee. 146pp.

Lincer, J.L., W.S. Clark, and M.N. LeFrance, Jr. 1979. Working bibliography of the bald eagle. National Wildlife Federation scientific/technical series No. 2. National Wildlife Federation, Washington, D.C. 219 pp.

Lish, J.S., and J.C. Lewis. 1975. Status and ecology of bald eagles wintering in Oklahoma. Proc. Of the 29th. Annual Conference of the Southeastern Association of Game and Fish Commissioners. Pp. 415-423.

MacCleery, D.W. 1992. American Forests- A History of Resiliency and Recovery. USDA Forest Service publ. FS-540. Forest History Society, Durham, North Carolina. 58pp.

Marbut, C.F. 1896. Surface features of Missouri. Missouri Geological Survey Report 10:14-109.

Martell, M. 1992. Bald eagle winter management guidelines. The Raptor Center, University of Minnesota publ., St. Paul, Minnesota. 14pp.

McEwan, L.C. and D.H. Hirth. 1979. Southern bald eagle productivity and nest site selection. J. *Wildl. Manage*. 42(1):86-92.

McFarland, C.A. 1998. Potential agricultural insecticide exposure of Indiana bats (*Myotis sodalis*) in Missouri. Unpubl. M..S. thesis, University of Missouri-Columbia. 256pp.

McGimsey, M.D., and R.D. Johnson. 1994. 1994 Gray bat cave survey report. Missouri Department of Conservation Unpub. Report, Jefferson City, Missouri. 79pp.

McGregor, R.L. 1977. Rare native vascular plants of Kansas. Tech. Publ. State Biol. Survey of Kansas 5:1-44.

McNab, W. H., and P.E. Avers. 1994. Ecological subregions of the United States: section descriptions. WO-WSA-5. U.S. Forest Service Publ.

Millar, J.G. 1995. Final Rule to reclassify the bald eagle from endangered to threatened in all of the lower 48 states. *Federal Register* 60(133):36000-36010.

Miller, N. E. 1996. Indiana bat summer habitat patterns in northern Missouri. Unpubl. M. S. thesis, University of Missouri-Columbia, Columbia, Missouri. 100pp.

Missouri Department of Conservation. 1992. Management plan for the Indiana bat and the gray bat in Missouri. Jefferson City, Missouri. 39pp.

Missouri Department of Conservation. 1994. 1994 gray bat cave survey report. Jefferson City, Missouri. 77pp.

Missouri Department of Conservation. 1997. Missouri Natural Heritage Database.

Missouri Department of Conservation. 1998. Missouri species of conservation concern checklist. Jefferson City, Missouri. 29pp.

Mohr, C.E. 1972. The status of threatened species of cave-dwelling bats. *Bull. Natl. Speleol. Soc.* 34:33-37.

Mumford, R. E. and J. B. Cope. 1958. Summer record of *Myotis sodalis* in Indiana. *J. Mamm.* 39:586-587.

Munro, J.A. 1938. The northern bald eagle in British Columbia. *Wilson Bull.* 50(1):28-35.

Myers, R. F. 1964. Ecology of three species of Myotine bats in the Ozark Plateau. Unpubl. Ph.D. Dissertation, Univ. of Missouri-Columbia, Columbia, MO 210pp.

Nelson, P.W. 1985. The terrestrial natural communities of Missouri. Missouri Department of Natural Resources, Jefferson City, Missouri. 197pp.

Nigh, T.A., W.L. Pflieger, P.L. Redfearn, W.A. Schroeder, A.R. Templeton, and F.R. Thompson III, 1992. The Biodiversity of Missouri- Definition, Status, and Recommendations for its Conservation. Biodiversity Task Force, Jefferson City, MO. 53pp.

Osterfeld, D.J. 1988. The communal night roosting of wintering bald eagles in west-central Illinois. Unpubl. M.S. Thesis. Western Illinois University, Macomb, Illinois. 106pp.

Petersen, J.C., J.C. Adamski, R.W. Bell, J.V. Davis, S.R. Femmer, D.A. Freiwald, and R.L. Joseph. 1998. Water quality in the Ozark Plateaus, Arkansas, Kansas, Missouri, and Oklahoma, 1992-95. U.S. Geological Survey Circular No. 1158, Denver, Colorado. 33pp.

Platt, J.B. 1976. Bald eagles wintering in a Utah desert. *Am. Birds* 30(4):783-788.

Racey, P. A. 1982. Ecology of bat reproduction. Pages 57-104 *in* T. H. Kunz, (ed.) Ecology of bats. Plenum Press, New York, NY. 425pp.

Reidinger, R. F. 1972. Factors influencing Arizona bat population levels. Unpubl. Ph.D. dissert., Univ. Ariz., Tucson, 172pp.

Reidinger, R. F. 1976. Organochlorine residues in adults of six southwestern bat species. *J. Wildl. Manage.*, 40:677-680.

Richter, A.R., S.R. Humphrey, J.B. Cope and V. Brack, Jr. 1993. Modified cave entrances: thermal effect on body mass and resulting decline of endangered Indiana bats (*Myotis sodalis*). *Conserv. Biol.* 7:407-415.

Robbins, M.B. and D.A. Easterla. 1992. Birds of Missouri- Their Distribution and Abundance. University of Missouri Press, Columbia. 399pp.

Romme, R.C., K. Tyrell and V. Brack, Jr. 1995. Literature summary and habitat suitability index model: components of summer habitat for the Indiana bat, *Myotis sodalis*. Report submitted to the Indiana Department of Natural Resources, Division of Wildlife, Bloomington, Indiana by 3D/Environmental, Cincinnati, Ohio. Federal Aid Project E-1-7, Study No. 8, 38 pp.

Sauer, C. O. 1920. The geography of the Ozark highland of Missouri. The Geographic Society of Chicago Bull. No. 7. University of Chicago Press, Chicago. 187pp.

Schaal, B., M. Bowles, D. Hayworth, & K. Williamson. 1993. Genetic variation in *Asclepias meadii* and its implications for re-introduction. Presentation at *Restoring diversity: is reintroduction an option for endangered plants?* Symposium by the Center for Plant Conservation, Missouri Botanical Garden, St. Louis, Missouri.

Schmauch, S. and M. Tuttle. 1998. Pilot Knob Mine site evaluation. Unpubl. Rep. to the U.S. Fish and Wildlife Service, Columbia, Missouri. 5pp.

Schroeder, W.A. 1981. Presettlement Prairie of Missouri. Missouri Department of Conservation, Jefferson City, MO. 35pp.

Schoolcraft, H.R. 1819. A view of the lead mines of Missouri. Wiley Printing Co., New York. 299pp.

Schoolcraft, H.R. 1821. Journal of a tour into the interior of Missouri and Arkansaw, from Potosi, or Mine'a Burton, in Missouri Territory, in a south-west direction, toward the Rocky Mountains- Performed in the years 1818 and 1819, Sir Richard Phillips and Co. London. 102pp.

Shifley, S.R., B.L. Brookshire, D.R. Larsen, L.A. Herbeck, and R.G. Jensen. 1997. Snags and down wood on upland oak sites in the Missouri Ozark Forest Ecosystem Project. Pages 248-256 in Proc. of the Missouri Ozark Project Symposium: an experimental approach to landscape

research, B.L. Brookshire and S.R. Shifley, eds. USDA- Forest Service General Tech. Rep. NC-193. St. Paul, MN. 378pp.

Southern, W.E. 1963. Winter populations, behavior and seasonal dispersal of bald eagles in northwestern Illinois. *Wilson Bull.* 75(1):42-55.

Southern, W.E. 1964. Additional observations on winter bald eagle populations: including remarks on biotelemetry techniques and immature plumages. *Wilson Bull.* 76(2):121-137.

Spencer, J.S., Jr., S.M. Roussopoulos, and R.A. Massengale. 1992. Missouri's forest resource, 1989: an analysis. USDA Forest Service- North Central Forest Experiment Station Bull. No. NC-139.

Stalmaster, M.V., and J.R. Newman. 1978. Behavioral responses of wintering bald eaglesto human activity. *J. Wildl. Manage.* 42(3):506-513.

Stalmaster, M.V., and J.R. Newman. 1979. Perch-site preferences of wintering bald eagles in northwest Washington. *J. Wildl. Manage.* 43(1):221-224.

Stalmaster, M.V., and J.A. Gessaman. 1984. Ecological energetics and foraging behavior of overwintering bald eagles. *Ecol. Monogr.* 54:407-428.

Stenhof, K. 1976. The ecology of wintering bald eagles in southeastern South Dakota. M.S. Thesis. University of Missouri, Columbia. 148pp.

Steenhof, K. 1978. Management of wintering bald eagles. USFWS Report FWS/OBS-78/79. Washington, D.C. 59pp.

Stenhof, K., S.S. Berlinger, and L.H. Fredickson. 1980. Habitat use by wintering bald eagles in South Dakota. *J. Wildl. Manage.* 44(4):798-805.

Stinson, E.R. and P.T. Bromley. 1991. Pesticides and wildlife, a guide to reducing impacts on animals and their habitat. Virginia Department of Game and Inland Fisheries Publ. 420-004. 44pp.

Swisher, J.F. 1964. A roosting area of the bald eagle in northern Utah. *Wilson Bull.* 76(2):186-187.

Tecic, D.L., J.L. McBride, M.L. Bowles, and D.L. Nickrent. 1998. Genetic variability in the Federal threatened Mead's milkweed, *Asclepias meadii* Torrey (ASCLEPIADACEAE). *Ann. Missouri. Bot. Gard.* 85: 97-109.

Thom, R.H., and J.H. Wilson. 1980. The Natural Divisions of Missouri. *Trans. of the Missouri*

Academy of Sci. 14:9-23.

Thomas, D. W., M. Dorais, and J. M. Bergeron. 1990. Winter energy budgets and cost of arousals for hibernating little brown bats (*Myotis lucifugus*). *J. Mamm.* 71:475-479.

Thomas, D. W., and D. Cloutier. 1992. Evaporative water loss by hibernating little brown bats, *Myotis lucifugus*. *Physiol. Zool.* 65:443-456.

Thomas, D. W. 1995. Hibernating bats are sensitive to non-tactile human disturbance. *J. Mamm.* 76:940-946.

3/D International, Inc. 1996. Biological Assessment of the Master Plan and Ongoing Mission, U.S. Army Engineer Center and Fort Leonard Wood, Missouri. Submitted to the U.S. Army Corps of Engineers, Kansas City District. 226 pp. + Appendices.

Thurman, C. M., and E. E. Hickey. 1989. Final Report- A Missouri survey of six species of Federal concern. Missouri Department of Conservation Unpubl. Report. Federal Aid Project SE-01-17, Jefferson City, Missouri. 99pp.

Tuttle, M.D. 1974. Population ecology of the gray bat (*Myotis grisescens*). Unpubl. Ph.D. dissertation, University of Kansas, Lawrence, Kansas. 109pp.

Tuttle, M.D. 1976a. Population ecology of the gray bat (*Myotis grisescens*): philopatry, timng and patterns of movement, weight loss during migration, and seasonal adaptive strategies. Occasional Papers of the Museum of Natural History- University of Kansas, Lawrence, Kansas. Number 54:1-38.

Tuttle, M.D. 1976b. Population ecology of the gray bat (*Myotis grisescens*): factors influencing growth and survival of newly volant young. *Ecology* 57:587-595.

Tuttle, M.D. 1979. Status, causes of decline, and management of endangered gray bats. *J. Wildl. Manage.* 43:1-17.

Tuttle, M. D. 1996. Wisconsin gains key bat sanctuary. *Bats* 14(4):3-7.

Tuttle, M. D., and D. A. R. Taylor. 1994. Bats and mines; Res. Publ. No. 3, Bat Conserv. Internat., Austin, TX 42pp.

Tuttle, M.D. and D.E. Stevenson. 1978. Variation in the cave environment and its biological implications in R. Zuber, *et al.* (eds.). National Cave Management Symposium Proceedings. 1977. Pp. 108-121. Speleobooks Adobe Press, Albuquerque, New Mexico. 140 pp.

Tyrell, L.E., G.J. Nowacki, T.R. Crow, D.S. Buckley, E.A. Nauertz, J.N. Niese, J.L. Rollinger,

and J.C. Zasada. 1998. Information about old growth for selected forest type groups in the e eastern United States. USDA Forest Service Gen. Tech. Rep. NC-197, St. Paul, MN- USDA, Forest Service, North Central Forest Experiment Station. 507pp.

U.S. Fish and Wildlife Service. 1982. Gray Bat Recovery Plan. USFWS, Twin Cities, Minnesota, 21pp. + Appendices.

U.S. Fish and Wildlife Service. 1983a. Northern States Bald Eagle Recovery Plan. USFWS, Twin Cities, Minnesota, 76 pp.

U.S. Fish and Wildlife Service. 1983b. Recovery plan for the Indiana bat. USFWS, Twin Cities, Minnesota, 80 pp.

U.S. Fish and Wildlife Service. 1999. Agency Draft Indiana Bat (*Myotis sodalis*) Revised Recovery Plan. Fort Snelling, Minnesota. 53pp.

U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998. Endangered Species Consultation Handbook- Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act. Washington, D.C.

U.S. Forest Service. 1986. Mark Twain National Forest Land and Resource Management Plan, Rolla, Missouri.

U.S. Forest Service. 1998. Mark Twain National Forest Programmatic Biological Assessment. Milwaukee, Wisconsin. 243pp.

Vian, W.E. 1971. The wintering bald eagle (*Haliaeetus leucocephalus*) on the Platte River in southcentral Nebraska. M.S.E. Thesis. Kearney State College, Kearney, Nebraska. 60pp.

Vineyard, J.D. and G.L. Feder. 1974. Springs of Missouri. Missouri Department of Natural Resources- Geological Survey and Water Resources Rep. WR 29. 272pp.

Voight, J.W., & R. H. Mohlenbrock. 1964. Plant communities of southern Illinois. Southern Illinois University Press, Carbondale. 202pp.

Watson, W.C. 1992. Final Report- inventory of southern Iowa for *Asclepias meadii* Torr. Unpub. report of the Iowa Field Office of the Nature Conservancy to the Iowa Department of Natural Resources, Des Moines. 41pp.

Watson, W.C. 1998. Final Report- site census of *Asclepias meadii* Torr. in Iowa. Unpub. report of the Iowa Field Office of the Nature Conservancy to the Iowa Department of Natural Resources, Des Moines and the U.S. Fish and Wildlife Service, Rock Island, Illinois. 10pp.

Whitaker, J. O., Jr. 1972. Food habits of bats from Indiana. *Canadian J. Zool.* 50:877-883.

White, D. H., and J. T. Seginak. 1987. Cave gate designs for use in protecting endangered bats. *Wildl. Soc. Bull.* 15:445-449.

Wiemeyer, S.N., C.M. Bunck, and C.J. Stafford. 1993. Environmental contaminants in bald eagle eggs–1980-84–and further interpretations of relationships to productivity and shell thickness. *Archives of Environmental Contamination and Toxicol.* 24:213-227.